AGRICULTURAL RESEARCH INSTITUTE

PUSA

VOL. 9 FIRST QUARTER, 1938 No. 1

The Philippine Journal of Agriculture

PUBLISHED QUARTERLY BY

THE DEPARTMENT OF AGRICULTURE AND COMMERCE

DEPARTMENT OF AGRICULTURE AND COMMERCE

HON. EULOGIO RODRIGUEZ, A.B., *Secretary*
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THE PHILIPPINE JOURNAL OF AGRICULTURE

Published quarterly by the DEPARTMENT OF AGRICULTURE AND COMMERCE
Editorial Offices: DIVISION OF PUBLICATIONS, Oriente Building, Plaza Binondo, Manila

[Entered at the Post Office at Manila, Philippines, as second-class matter]

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VARIETY TESTS OF CABBAGE

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FOURTEEN PLATES

The cabbage, *Brassica oleracea* var, *capitata* Hort., is one of the most successful among semi-temperate vegetable immigrants in the Philippines. In the near future, it may become one of the leading and perhaps, the most popular vegetable here. The first introduction of this vegetable into the Islands is not definitely known. While its early successful cultures were confined at medium and high altitudes like Baguio and Trinidad Valley, Mountain Province (1933), a few trials (1924) in the lowland also showed great possibilities. As early as 1910, cabbage was successfully grown under a semi-commercial scale in the Batac Rural High School, Batac, Ilocos Norte. In Manila and its suburbs, cabbage has been under cultivation for long under Chinese gardeners although in a limited scale.

The present work was undertaken because of the demand for more information about cabbage culture in the lowlands. At the same time it was deemed necessary to find varieties that are best adapted to conditions in the plains. The discovery of the best varieties for lowland cultures—for early and late planting—would certainly be a very valuable information to vegetable growers and truckers.

The work was first undertaken at the defunct Alabang Rice Station, Rizal; then the work was transferred to the Central Experiment Station, Manila; to the Lipa Coffee–Citrus Station,

Lipa, Batangas Province; and to the Los Baños Economic Garden, Los Baños, Laguna. The study was started in November, 1932 and completed in March, 1937.

MATERIALS AND METHODS

Because of the fact that cabbage seed is not yet commercially produced in the Islands, the different varieties used in this study were imported from the United States, England, and China. Table 1 gives a list of the varieties tested, and the seedhouse and country of origin.

TABLE 1.—*Showing the names of the varieties tested and the country of origin*

Variety name	Seedhouse or company	Country of origin
Allhead Early	W. Atlee Burpee Co., Pa., Penn.	U. S. A.
Allhead Select	do	Do.
All Seasons	do	Do.
Autumn King	Peter Henderson & Co., N. Y.	Do.
Charleston Wakefield	do	Do.
Copenhagen Market	do	Do.
Danish Ballhead	Local Seed store	Do.
Danish Roundhead	W. Atlee Burpee Co., Pa., Penn.	Do.
Early Dwarf Flat Dutch	do	Do.
Early Jersey Wakefield	do	Do.
Early Krop	Peter Henderson & Co., N. Y.	Do.
Early Market	do	Do.
Early Stonehead	W. Atlee Burpee Co., Pa., Penn.	Do.
Early Summer	Peter Henderson & Co., N. Y.	Do.
Early Winnigstadt	W. Atlee Burpee Co., Pa , Penn.	Do.
Entrkhuizen Glory	do	Do.
Golden Acre	Peter Henderson & Co., N. Y.	Do.
Henderson Premier	do	Do.
Late Flat Dutch	do	Do.
Penn State Ballhead	W. Atlee Burpee Co., Pa., Penn.	Do.
Premier Flat Dutch	do	Do.
Red Dutch	Peter Henderson & Co., N. Y.	Do.
Round Red Dutch	W. Atlee Burpee Co., Pa., Penn.	Do.
Shanghai	Local seed store	China.
Special Succession	Steckler Seed Co., Inc., La.	U. S. A.
Stein's Flat Dutch	Peter Henderson & Co., N. Y.	Do.
Succession	W. Atlee Burpee Co., Pa., Penn.	Do.
Surehead	do	Do.
Sutton's Allheart	Sutton and Sons, Reading	England.
Sutton's Earliest	do	Do.
Sutton's Favorite	do	Do.
Sutton's Flower of Spring	do	Do.
Sutton's Maincrop	do	Do.

In this study, the varieties tested were not all planted throughout the duration of the experiment, neither were they planted at

the same time. From 10 to 15 different varieties were tested in one year. The method followed was by trial and elimination, that is, out of a number of varieties tested in the first year, only those found promising by actual performance, and another batch of new varieties, to take the places of those eliminated, were ordered for planting the following year. So that it will be seen that some varieties were tested continuously, while others were only tested in a year, two or more.

DESCRIPTION OF VARIETIES

The aim here is to give some of the distinguishing characteristics of the varieties that have been tried in this study. Owing to the fact that over 30 varieties were included in this study, only the varieties that were found promising and those possessing some special merit are described. The work of Boswell *et al.* (1934) on the description of types of American cabbage varieties was freely consulted.

It may be stated here that during the course of the study, the different varieties showed distinguishable variations not only in the number of days to maturity but also in foliage characteristic, head formation, etc. as has also been reported in the United States by Boswell *et al.* (1934).

Allhead Early.—One of the best yielding varieties tested. Plant large but rather dwarf; leaves large, not numerous, lower ones quite spreading, bases spatulate to petioled. Leaves near head do not stand well above head thus exposing them to good view. Ribs medium, veins though not big are conspicuous. Bloom medium heavy, color of leaf gray green. Head big, round to rather flat on top, wider than thick. Head rather compact, although rather loose at lower portions. Core medium large, length about 50 per cent of head (Plate 4).

Allhead Select.—Has the general characteristics of Allhead Early. The plant, however, is smaller, and the head seems to be more compact (Plate 5).

Autumn King.—Plant large; leaves large, petioled, lower ones spreading and upper curving upward forming a cup-like appearance. Ribs and veins quite prominent; bloom rather heavy, leaf color light gray green. Head round to oblong, with few outer leaves; cross-section circular. Head quite hard and compact, core medium, length about 50 per cent of head (Plate 10).

Charleston Wakefield.—The best yielder among those with pointed heads. Sometimes called Large Wakefield. Plant me-

dium large, appearing somewhat like Early Jersey Wakefield. Leaves large and spreading, ribs and veins prominent; bloom medium thus appearing lighter in color than Early Jersey Wakefield. Stem medium size and generally short. Head pointed, medium size, approximately circular in cross-section. Moderately firm, though not very hard. Core medium size, about 45 to 50 per cent of length of head (Plate 6).

Copenhagen Market.—An early maturing variety of medium size. Leaves medium in number although at times numerous resulting in small head. Leaves distinctly and uniformly curved and appearing like the bowl of a rounded spoon. Plant with heads have a characteristic of well-trimmed and glossy appearance. Ribs and veins are medium size, but conspicuous because of light color. Stem small and short. Head more or less spherical, medium size and is generally hard and compact. Core about 55 per cent thickness of the head.

Danish Roundhead.—Plant medium size; leaves medium, spatulate at base and rather closely arranged forming a cup-like appearance. Inner leaves stand well over head. Ribs rather small, veins inconspicuous; bloom quite heavy. Stem small but rather long. Head small to medium size, round and hard. Leaves inside well compact on upper portion of head, but rather loose at the base. Core medium large, length about 66 per cent of head (Plate 14).

Early Flat Dutch.—Similar to Stein's Flat Dutch (Plate 12).

Early Jersey Wakefield.—A popular early maturing variety of the heart-shaped types. Plant small with few outside leaves, rarely petioled, smooth dark green; bloom slight, and veins not prominent. Stem small and short. Head small and pointed, firm but not very hard. Core medium, length about 50 per cent of the head.

Early Market.—A small round-headed variety, early maturing. Few outer leaves that curve inward thus protecting the head. Leaves and veins free from coarseness. The head is small, round and compact and has the tendency to become hard before full development.

Early Stonehead.—Plant large; leaves large, spreading, base petioled, leaf-blade rather curl. Ribs and veins rather prominent. Bloom quite heavy, leaf color silver gray. Stem medium large, but short, internodes short. Head medium to large, more or less spherical, hard, inside leaves crumpled and compact, cross-section circular. Core small, length 25 to 30 per cent of

head (Plate 11). Eating quality excellent, cabbage odor not pronounced.

Early Winnigstadt.—Plant medium large: leaves large, bases usually distinctly petioled, ribs and veins quite prominent, bloom heavy, leaf color distinctly greenish gray. Stem medium size, rather long. Head small to medium size, pointed; cross-section circular. Top of head small pointed with tips of outer leaves forming tuff about point. Head rather loose; core small but long about 50 to 55 per cent of head (Plate 13).

Enkhuizen Glory.—Plant of medium size; leaves quite numerous, rarely petioled, curved upward and extending slightly above head. Ribs and veins quite conspicuous; bloom rather heavy, leaf color gray-green. Stem small and short. Head more or less spherical, medium size with circular cross-section. Head very hard with interior leaves crumpled but compact. Core medium, length about 45 to 50 per cent of head (Plate 9). Texture tender and crisp, flavor good.

Golden Acre.—A small but early variety. Leaves few, rib and veins rather prominent. Bloom medium heavy. Head generally round and firm, and is capable of remaining in the field for a long time without bolting. Quality fine.

Henderson Premier.—Small and early maturing—round headed. Plant is compact and can be planted closer than other small varieties. Head very firm, tender and succulent. Very good for salad purposes.

Late Flat Dutch.—Plant very large and of open spreading appearance; leaves numerous, bases spatulate to petioled, blades curved upward slightly; leaves near head erect, standing well above top of head. Ribs and veins quite prominent; bloom heavy, leaf color light gray green. Head generally flat, large; cross-section more or less circular. Head quite hard, leaves inside crumpled and medium compact. Core medium large, length about 50 per cent of head (Plate 8).

Premium Flat Dutch.—Very similar to Late Flat Dutch in appearance and field characteristics.

Shanghai.—A Chinese variety, extensively grown in Baguio and Trinidad Valley because of its adaptability to rainy season culture, its high resistance to fungus diseases and because of its heavy production. Plant enormously large, maturing in 5 to 6 months. Leaves numerous with silvery gray color with lower ones spreading. Bases generally petioled, ribs and veins quite prominent; bloom heavy; stem large and quite long. Head very

big, round to rather flat in shape, medium hard, leaves inside crumpled and not so compact particularly at the lower portions. Core large, length about 50 to 55 per cent of head. Quality very poor and coarse, and has a very objectionable strong "cabbage" odor. Has the tendency to flower under Philippine conditions.

Special Succession.—Similar to Succession (Plate 2).

Stein's Flat Dutch.—Plant medium in size; leaves quite numerous, generally spatulate at bases, blade turn upward resembling a cup-like formation. Ribs and veins not so prominent, bloom quite heavy. Head medium large, and top generally flattened. Head rather hard and compact. Core medium large, length about 50 to 55 per cent of head (Plate 12).

Succession.—The best all season cabbage variety among those tested in the lowland, a heavy yielder and a sure cropper.

Plant large; leaves large but rather few, blade uniformly curved upward presenting a distinctly cup-shaped appearance and exposing the head to good view. Leaves generally spatulate at base, ribs and veins free from coarseness but characteristically conspicuous; bloom medium heavy; leaf color, light gray green. Stem medium large, rather short. Head big, more flattened than round; cross-section circular. The heads become solid long before it is fully grown so that heads of good size may be harvested before attaining full size. Head is hard with interior leaves crumpled but compact. Core medium large, length about 50 per cent of head (Plate 3).

Surehead.—Plant medium size; leaves quite numerous, base spatulate to petioled; blade curved slightly upward; leaves near head erect, standing well above it. Ribs and veins quite prominent; bloom medium heavy. Head medium size, round to flat; cross-section circular. Core medium large, length about 50 per cent of head (Plate 7).

CULTURES

In this study, 14 sets of planting were made covering a period of five years, from 1932 to the first half of 1937, inclusive. The cultures were conducted in four different experiment stations of the Bureau of Plant Industry; namely, the defunct Alabang Rice Station, Muntinlupa, Rizal; the Central Experiment Station, Manila; Lipa Coffee-Citrus Station, Lipa, Batangas; and the Los Baños Economic Garden, Los Baños, Laguna. Table 2 gives the different sets of cultures, the year when they were conducted and also the experiment stations where they were undertaken.

TABLE 2.—*Showing where the different cultures were undertaken and the year when conducted*

Vegetable season when cultures were made	Culture	Experiment Station where cultures were made
1932–1933	A	Alabang Rice Station, Muntinglupa, Rizal.
1933–1934	B	Central Experiment Station, Manila.
Do.	C	Do.
Do.	D	Lipa, Coffee-Citrus Station, Lipa, Batangas.
Do.	E	Do.
1934–1935	F	Central Experiment Station, Manila
Do.	G	Do.
Do.	H	Los Baños Economic Garden, Los Baños, Laguna.
Do.	I	Do.
1935–1936	J	Central Experiment Station, Manila.
Do.	K	Los Baños Economic Garden, Los Baños, Laguna.
1936–1937	L	Central Experiment Station, Manila.
Do.	M	Lipa, Coffee-Citrus Station, Lipa, Batangas.
Do.	N	Los Baños Economic Garden, Los Baños, Laguna.

Culture A was undertaken by the senior author alone at the defunct Alabang Rice Station during the 1932–1933 vegetable season. The field was of gentle slope and the soil was from medium to heavy clay in texture. Since this was the first attempt at growing cabbage in that station, and station employees as well as neighboring farmers were rather skeptical as to the success of the trial, some extra treatment was provided in the preparation of the soil for planting. This was deemed necessary because of the heavy nature of the soil. This treatment consisted in putting one shovelful of well-rotted stable manure in each of the holes into which the seedlings were to be set in. The holes were spaced 50 centimeters apart in rows set at 60 centimeters far apart. The cabbage seedlings were set in the manure without being mixed with the soil, in order to have a mellow medium for the roots of the young plants to develop.

The varieties used in Culture A were Autumn King, Copenhagen Market, Danish Ballhead, Early Market, Early Summer, Stein's Flat Dutch and Succession. In Cultures B, C, D, and E the varieties Allhead Early, Charleston Wakefield, Copenhagen Market, Early Jersey Wakefield, Early Krop, Early Market, Golden Acre, Henderson Premier, Red Dutch, and Succession were used. For Culture F, the varieties Charleston Wakefield, Early Dwarf Flat Dutch, Early Jersey Wakefield, Golden Acre, Late Flat Dutch, Henderson Premier, Shanghai and Succession were tested. The same varieties with the exception of Early Dwarf Flat Dutch, Early Jersey Wakefield and Shanghai were used in Culture G. Sutton's Allheart, Sutton's Earliest, Sutton's

Favorite, Sutton's Flower of Spring and Sutton's Maincrop were also tested in Culture G. Five varieties were tested in Culture H; namely, Charleston Wakefield, Golden Acre, Henderson Premier, Late Flat Dutch, and Succession. With the exception of Henderson Premier, the same varieties were tested in Culture I in addition to Sutton's Allheart, Sutton's Earliest, Sutton's Favorite, Sutton's Flower of Spring and Sutton's Maincrop. In Cultures J and K the following varieties were tested: Allhead Early, Charleston Wakefield, Danish Ballhead, Early Winnigstadt, Enkhuizen Glory, Penn State Ballhead, Premium Flat Dutch, Round Red Dutch, Special Succession, Succession, and Surehead. In Cultures L, M, and N, 14 varieties were included in the study; namely, Allhead Early, Allhead Select, All Seasons, Autumn King, Charleston Wakefield, Danish Roundhead, Early Stonehead, Enkhuizen Glory, Golden Acre, Penn State Ballhead, Premium Flat Dutch, Stein's Flat Dutch, Succession, and Surehead.

With the exception of the soil of the Central Experiment Station plots which was comparatively deep sandy loam, the soils of the culture plots in the Lipa Coffee-Citrus Station and in the Los Baños Economic Garden were loamy in nature and comparatively shallow, the depth ranging from about 40 to 60 centimeters, and underlaid with adobe soil. The ground, nevertheless, had very gentle slope and the soils were fairly uniform. No attempt, however, was made to determine the comparative fertility of the soils in the different stations.

In all the cultures, the same method of planting was used—the bed system—each bed containing two rows. The seedlings were raised first in seed beds and when they were from 4 to 5 weeks old, they were transplanted in the garden plots. The actual distancing in the beds was 60 centimeters between the rows, and 50 centimeters between the plants in the rows. However, because of the allowances for paths between beds, the distancing on the hectare basis would be 75 centimeters between rows and 50 centimeters between plants so that in a hectare there would be 26,667 plants.

In the gathering of data, the weight of the cabbage head or the yield of a plot was considered as the main criterion for comparison. Also, the number of days to maturity, the comparative solidity of the head, the relative resistance to pests and diseases and their eating quality were noted. However, no critical study of these latter characters was attempted.

In the different tests, either the plant or the plot was considered as the unit. In some cases some of the seeds ordered had poor germination thus limiting the number of seedlings obtainable for transplanting. Where one or more varieties were represented only by a plot, the plant was considered as the unit for that set of culture; but in cases where two or more plots were used for the variety with the least number of representative plants, the plot was considered as the unit.

As much as possible, the different sets of cultures were given practically the same treatments, especially with respect to cultivation and weeding, watering, spraying and fertilizing. While the spacing between rows and plants was maintained throughout, the size of the plots in the different cultures could not be made of equal area.

Because of the great bulk of the data gathered in this study, only the summary of the results of each culture is presented here. The complete original data were filed with the Horticulture Section of this Bureau.

EXPERIMENTS AND RESULTS

Culture A.—This study was undertaken from December, 1932 to March, 1933. The planting was rather late and the crop was affected by the easterly wind prevalent from February to April. In spite of the heavy nature of the soil and the rather late planting, the stand of the crop was good. Seven varieties were included in this study. Table 3 gives a summary of the results of this culture giving the number of days to maturity, per cent heading, the average weight per head, and the computed yield per hectare.

TABLE 3.—*Showing the number of days to maturity, per cent heading and yield of different cabbage varieties at the Alabang Rice Station*

(CULTURE A)

Variety name	Days to maturity	Per cent heading	Average weight per head	Yield per hectare[1]
			Kilo	*Kilo*
Autumn King	92–109	88	0.54±0.017	12,672
Copenhagen Market	81–102	98	0.72±0.016	18,816
Danish Ballhead	90–108	90	0.27±0.009	6,480
Early Market	80–102	98	0.57±0.017	14,896
Early Summer	92–108	98	0.55±0.020	14,374
Stein's Flat Dutch	90–109	75	0.57±0.008	11,400
Succession	83–106	97	0.83±0.026	21,476

[1] The yield was computed on the basis of 26,667 plants (50 × 75 centimeters) per hectare.

Cultures B and C.—Both of these cultures were undertaken during the 1933–1934 vegetable season at the Central Experiment Station. Culture B took place from January to March, 1934, and Culture C, from February to April of the same year. Ten varieties were tested in both cultures. Table 4 presents a summary of the results of these cultures.

TABLE 4.—*Comparative yields of different varieties of cabbage at the Central Experiment Station, Manila, 1933–1934 vegetable season*

Variety name	January–March, 1934 planting (Culture B)			February–April, 1934 planting (Culture C)		
	Per cent heading	Average weight per head	Computed yield per hectare[1]	Per cent heading	Average weight per head	Computed yield per hectare[1]
		Grams	*Kilos*		*Grams*	*Kilos*
Allhead Early	95	614.3±33.38	15,562	92	490.5±23 96	12,034
Charleston Wakefield	100	602 7±34 39	16,072	82	686.3±21.15	15,007
Copenhagen Market	74	463.0±28 28	9,137	63	364.2±19.74	6,119
Early Jersey Wakefield	85	402.0±19 74	9,112	66	461.3±21.54	8,119
Early Krop	93	324.5±23 81	8,048	61	369.1±15 13	6,004
Early Market	85	237.3±15 11	5,379	82	391.6±18.62	8,563
Golden Acre	93	378.2±22 29	9,379	100	425.2±22 69	11,339
Henderson Premier	90	331 6±16.59	7,959	92	469.7±18.54	11,523
Red Dutch	83	175.7± 9.13	4,685	82	263.5±15 25	5,762
Succession	100	568.5±26 17	15,160	100	688.1±27 25	18 350

[1] The yield was computed on the basis of 26,667 plants (50 × 75 centimeters) per hectare.

Cultures D and E.—These cultures were also undertaken during the 1933–1934 vegetable season at the Lipa Coffee-Cetrus Station. Culture D took place from November, 1933 to February, 1934, while Culture E, from January to April, 1934. Ten varieties were tested in these studies. Both cultures were good, especially the first. Table 5 presents a summary of the results of these cultures.

Cultures F and G.—These cultures took place during the 1934–1935 vegetable season at the Central Experiment Station in Manila. Culture F was planted in October, 1934, while Culture G, in December of the same year. Eight varieties were tested in both cultures. Table 6 gives a summary of the results of said cultures.

TABLE 5.—*Showing the comparative yields of different varieties of cabbage at the Lipa Coffee-Citrus Station*

Variety name	November-February, 1934 planting (Culture D)			January-April, 1934 planting (Culture E)		
	Area of plot	Average yield of plot	Computed yield per hectare	Area of plot	Average yield of plot	Computed yield per hectare
	Sq. m.	*Kilos*	*Kilos*	*Sq. m*	*Kilos*	*Kilos*
Allhead Early	11 25	43 40±1 36	38,578	11 25	21 25±0 51	18,889
Charleston Wakefield	11.25	28.92±1.19	25,707	11 25	19 15±0 81	17,022
Copenhagen Market	11 25	15 61±0 57	13,876	11.25	12 86±0.65	11,431
Early Jersey Wakefield	11.25	19 72±1.22	17,520	11 25	18 36±0.99	16,320
Early Krop	11.25	13 42±0.38	11,929	11.25	15.59±0.70	13 857
Early Market	11.25	17.53±0.70	15,581	11.25	15 90±0.36	14,133
Golden Acre	11.25	17 02±0 54	15,129	11 25	16 75±0 77	14 889
Henderson Premier	11 25	14 92±1.21	13,262	11 25	14 99±0.52	13,324
Red Dutch	11.25	10 96±0.36	8,853	11.25	7 28±0.68	6,471
Succession	11.25	54.01±1.36	48,009	11.25	25.38±1 01	22,471

TABLE 6.—*Comparative yields of different varieties of cabbage at the Central Experiment Station, 1934–1935 vegetable season*

Variety name	Planted, October, 1934 (Culture F)			Planted, December, 1934 (Culture G)		
	Per cent heading	Average weight per head	Computed yield per hectare[1]	Per cent heading	Average weight per head	Computed yield per hectare[1]
		Grams	*Kilos*		*Grams*	*Kilos*
Charleston Wakefield	75	495.9±29.03	9,918	98	631.4±23.89	16 501
Early Dwarf Flat Dutch	83	156 2±10.87	3,457			
Early Jersey Wakefield	70	299.5±15 90	5,217			
Golden Acre	78	319.0±14.04	6,635	98	376.4±12.66	9 837
Late Flat Dutch	96	761.3±38.61	19,287	83	675.6±30.68	15,074
Henderson Premier	78	213.5±13.84	4 441	93	364 2±16 66	9,032
Shanghai	43	1317.0±62.22	15,102			
Succession	98	560.0±38.15	14,635	95	894.6±31.48	22,483
Sutton's Allheart				57	444.7±24.35	6,759
Sutton's Earliest				71	276.3±12.57	5,231
Sutton's Favorite				19	272.1±24.68	1,379
Sutton's Flower of Spring				(2)		
Sutton's Mainkrop				(2)		

[1] The yield was computed on the basis of 26,667 plants (50 × 75 centimeters) per hectare.
[2] Did not produce any head in spite of good vegetative growth.

Cultures H and I.—These cultures were run in the Los Baños Economic Garden during the 1934–1935 vegetable season. Culture H which was composed of five varieties was started in December, 1934, while Culture I was started in January, 1935. In the latter culture nine varieties were studied. A summary of the results of both cultures is presented in Table 7.

TABLE 7.—*Comparative yields of different varieties of cabbage at the Los Baños Economic Garden, 1934–1935 vegetable season*

Variety name	Planted, December, 1934 (Culture H)			Planted, January, 1935 (Culture I)		
	Per cent heading	Average yield per plot	Computed yield per hectare	Per cent heading	Average yield per plot	Computed yield per hectare
		Kilos	*Kilos*		*Kilos*	*Kilos*
Charleston Wakefield	95	17.04 ±0.45	18,933	89	11.03 ±0.41	12,256
Golden Acre	95	9.48 ±0.19	10,633	91	9 49 ±0 19	10,544
Henderson Premier	97	8.54 ±0.21	9,489			
Late Flat Dutch	94	22 17 ±0 60	24,633	83	11.86 ±0 61	13,178
Succession	97	17.94 ±0.37	19,933	87	11.99 ±0 49	13,322
Sutton's Allheart				22	3.08 ±0 19	3,311
Sutton's Earliest				70	4 73 ±0 28	5,255
Sutton's Favorite				22	1.22 ±0.18	1,355
Sutton's Flower of Spring				11	0.70 ±0.11	778
Sutton's Mainkrop				2	0.16 ±0.30	178

Cultures J and K.—Both cultures were undertaken during the 1935–1936 vegetable season. Culture J was conducted at the Central Experiment Station while Culture K, at the Los Baños Economic Garden. Ten varieties were tested in Culture J while 11 varieties in Culture K. Table 8 gives a summary of the results of both cultures.

Cultures L, M, and N.—These cultures were conducted during the 1936–1937 vegetable season. Culture L was undertaken at the Central Experiment Station, Culture M, at the Lipa Coffee-Citrus Station, and Culture N, at the Los Baños Economic Garden. Culture N was a total failure because of the typhoon that struck the Los Baños Economic Garden when the seedlings were being raised. Culture M, on the other hand, was badly damaged by soft rot, hence it was deemed necessary to exclude the data obtained. Table 9 presents a summary of the results of Culture L.

TABLE 8.—*Comparative yields of different cabbage varieties at the Central Experiment Station and Los Baños Economic Garden, 1935–1936 vegetable season.*

Variety name	Test at Central Experiment Station (Culture J)			Test at Los Baños Economic Garden (Culture K)		
	Area of plot	Average yield per plot	Computed yield per hectare	Area of plot	Average yield per plot	Computed yield per hectare
	Sq. m.	*Kilos*	*Kilos*	*Sq. m.*	*Kilos*	*Kilos*
Allhead Early	5.5	2.87±0.06	5,218	16.5	25.32±0.86	15,345
Charleston Wakefield	5.5	7.09±0.39	12,892	16.5	18.17±1.33	11,012
Danish Ballhead	5.5	3.35±0.43	6,092	16.5	17.00±0 84	10,303
Early Winnigstadt	5.5	5.43±0.21	9,873	16.5	10.88±2.71	6,594
Enkhuizen Glory	5.5	7.15±0.23	13,000	16.5	27.12∓1.95	16 436
Penn State Ballhead	5.5	6.71±0.48	12,200	16.5	15.63±0.91	9,473
Premium Flat Dutch	5.5	3.88±0.82	7,055	16.5	32.90±1.85	19,939
Round Red Dutch	5.5			16.5	0.95±0.06	576
Special Succession	5.5	16.55±0.44	30,091	16.5	27.04±0.68	16,388
Succession [1]	5.5	7.65±0.02	13,909	16.5	30.38±2.73	18,412
Surehead	5.5	7.86±1.95	14,291	16.5	30.22±1.77	18,315

[1] These varieties in Culture J were badly attacked by worms before spraying was started, and consequently produced small sized-heads.

TABLE 9.—*Comparative yields of different varieties of cabbage at the Central Experiment Station, 1936–1937 vegetable season*

(CULTURE L)

Variety name	Days to mature	Per cent heading	Average weight per head	Yield per hectare [1]
			Kilos	*Kilos*
Allhead Early	101–132	87	0.83±0.064	19,257
Allhead Select	95–126	91	0.71±0.031	17,230
All Season	95–132	91	0.60±0.040	14,560
Autumn King	103–132	87	0.65±0.030	15,081
Charleston Wakefield	95–132	88	0.60±0.049	14,080
Danish Roundhead	101–132	48	0.44±0.073	5,632
Early Stonehead	103–132	85	0.59±0.029	13,374
Enkhuizen Glory	95–132	91	0.62±0.036	15,046
Golden Acre	86– 93	85	0.38±0.027	8,613
Penn State Ballhead	95–132	94	0.43±0.028	10,779
Premium Flat Dutch	95–132	85	0.84±0.062	19,040
Stein's Flat Dutch	95–132	91	0.61±0.043	14,803
Succession	93–106	94	0.58±0.019	14,539
Surehead	95–132	78	0.65±0.046	13,521

[1] The yield was computed on the basis of 26,667 plants (50 × 75 centimeters) per hectare.

In order to find the average yields of the different varieties as tested for a series of years in the different Stations, Tables 10, 11, 12 and 13 were prepared. Table 10 presents the average yields by stations of the varieties tested during the whole duration of the study at the Alabang Rice Station, Lipa Coffee-Citrus Station and Los Baños Economic Garden, while Table 11 gives the average yields of the varieties tested at the Central Experiment Station. Table 12, on the other hand, does not only give the average yields of the varieties tested at the Central Experiment Station, Lipa Coffee-Citrus Station and Los Baños Economic Garden, but it also gives the range in yields of the different varieties in the different stations and the number of tests or cultures made in each station.

Table 13 presents a summary of Tables 10, 11, and 12, giving the average yields of the different varieties as tested in the different stations. In addition, this table presents the range of yield of each variety, the number of stations where the tests were made, and the number of tests conducted.

Table 14 gives a list of the 15 best varieties in the order of their yielding capacity during the whole duration of the study.

DISCUSSION OF RESULTS

Contrary to the common belief that cabbage could be raised successfully only at high elevations like Baguio and Trinidad Valley, Mountain Province, Nueva Vizcaya and other high places, this study presents definite information that cabbage can be profitably grown also at sea level.

TEST AT THE ALABANG RICE STATION

One test was conducted at the defunct Alabang Rice Station. As seen in Table 3, all the varieties tested readily formed heads, the percentage of heading ranged from 75 in the case of Stein's Flat Dutch to 98 in the case of Copenhagen Market, Early Summer, and Early Market. The number of days to maturity ranged from 80 to 109 days—from sowing of seed to harvesting of the crop. Early Market, Copenhagen Market, and Succession were the earliest to mature. Succession in the first test was considered an early maturing variety because of the lack of acquaintance with the fact that the head of this variety becomes hard long before it is fully developed (1934). As has been found in subsequent tests, Succession is a medium maturing variety.

The average weight per head varied from 0.27 ± 0.009 to 0.83 ± 0.026 kilos based from 70 to 100 heads per variety. The best yielder was Succession with an average weight per head of 0.83 ± 0.026 kilos or a computed yield of 21,470 kilos a hectare followed by Copenhagen Market with a computed yield of 18,816 kilos per hectare (see Table 3). The poorest yielder was Danish Ballhead.

TESTS AT THE LIPA COFFEE-CITRUS STATION

Three tests were conducted in this station, two in 1933–1934 vegetable season and one in 1936–1937 season. Because of the severe attacks of soft rot, only the results of the first two cultures are presented in this report. As seen in Table 5, of the 10 varieties tested, Succession was the best yielder in both tests (Cultures D and E), the average computed yields per hectare being 48,009 and 22,471 kilos, respectively. The second best yielder (in these cultures) was Allhead Early with average yields of 38,578 and 18,889 kilos per hectare, followed by Charleston Wakefield and Early Jersey Wakefield.

It will be noted in Table 5 that as a rule Culture D (early dry season planting) gave higher yields than Culture E (late dry season planting). It was only in the case of Red Dutch, Early Krop and Henderson Premier that the latter culture gave higher yields. It is also interesting to note that the first four best yielders in the first test (Culture D) were also the first four best in the second best (Culture E).

TESTS AT THE LOS BAÑOS ECONOMIC GARDEN

As seen in Table 2, four cultures were conducted at the Los Baños Economic Garden during three vegetable seasons, 1934–1937, inclusive. Nineteen varieties were tested, and the different varieties were tested from one to three times.

The first and second cultures were conducted in the same year. In the first test (Culture H), five varieties were tested. The per cent heading of the varieties tested was high, ranging from 94 in the case of Late Flat Dutch to 97 in the case of Succession. The yield of these varieties varied from 9,489 to 24,633 kilograms per hectare. Late Flat Dutch was the best yielder with an average yield of 24,633 kilograms; Succession, second with an average yield of 19,933 kilograms; and Charleston Wakefield third with an average yield of 18,933 kilograms per hectare (see Table 7).

In the second test (Culture I), 9 varieties were tested. In this test, the per cent heading was rather low, ranging from 2 per cent in the case of Sutton's Maincrop to 91 per cent in the case of Golden Acre. As seen in Table 7, the yield was also poor; the yield ranged from 178 to 13,322 kilograms per hectare. It will be noted, however, that the best three yielders in the first test were also the best three in this test, although not in the same order. The best three yielders in this test in the order of their importance were Succession, Late Flat Dutch, and Charleston Wakefield with the corresponding yields of 13,322, 13,178 and 12,256 kilograms per hectare.

The third test (Culture K) at the Los Baños Economic Garden brought in new varieties that yielded about as much as the best in previous cultures. The promising new varieties in this test were Premium Flat Dutch, Surehead, Enkhuizen Glory, Special Succession and Allhead Early, the average yields of which being 19,939, 18,315, 16,436, 16,388 and 15,345 kilograms per hectare, respectively (see Table 8). Succession which was one of the best in Cultures H and I, gave a yield of 18,412 kilograms per hectare while Charleston Wakefield gave a yield of only 11,012 kilograms to the hectare.

Summing the results of the three cultures at the Los Baños Economic Garden which included 19 varieties, it may be stated that the yield per hectare ranged from 178 to 24,633 kilograms (see Tables 11 and 12). It is apparent from the results obtained that there were a number of varieties adapted to the conditions obtaining in the Los Baños Economic Garden and its environs. The best varieties so far found were Premier Flat Dutch, Late Flat Dutch, Surehead, Succession, Enkhuizen Glory, Special Succession, Allhead Early, and Charleston Wakefield.

TESTS AT THE CENTRAL EXPERIMENT STATION

As seen in Table 2, six cultures (B, C, F, G, J, and L) were conducted at the Central Experiment Station for a period of four vegetable seasons (1933–1937). Thirty varieties were tested during this period.

1933–1934 tests.—Two sets of cultures (Cultures B and C) were conducted during this season. In both cultures, the same ten varieties were tested. The general stand of the crops was good; the per cent heading in Culture B was from 74 to 100, and from 61 to 100 per cent in Culture C. The average computed yield per hectare in Culture B was from 4,685 to 16,072 kilo-

grams, and from 5,762 to 18,350 kilograms per hectare in Culture C. The best yielders in Culture B were Charleston Wakefield, Succession, and Allhead Early; while in Culture C the best yielders were Succession, Charleston Wakefield, and Allhead Early (see Table 5). Like in the Lipa Coffee-Citrus Station tests, the best yielders found in the early planting were also the best in the late planting.

1934–1935 test.—In the first planting (Culture F) eight varieties were tested including the Shanghai cabbage which is commonly grown in Baguio and Trinidad Valley during the rainy season (1933). The per cent heading varied from 43 in the case of Shanghai to 98 in the case of Succession, and the yield ranged from 3,457 to 19,287 kilograms per hectare. Late Flat Dutch was the best yielder, followed by Shanghai, and Succession was third. While Late Flat Dutch was the best in yield, Shanghai has the biggest head, averaging in weight, 1.317 ± 0.062 kilograms a head as against 0.761 ± 0.039 kilograms of Late Flat Dutch, and 0.560 ± 0.038 kilograms for Succession. Shanghai, however, had a very low percentage heading (see Table 6) and is a very late maturing variety.

In the second culture (Culture G), which was planted in December, 1934, Succession was the heaviest yielder with 22,483 kilograms per hectare to its credit; Charleston Wakefield, second; and Late Flat Dutch, third, the average yields being 16,501 and 15,074 kilograms per hectare, respectively (see Table 6).

Of the five English varieties tested, two did not produce heads at all in spite of excellent vegetative growth while the other three varieties had a percentage heading ranging from 19 to 71. This indifferent performance of the English varieties was similar to their showing in the Los Baños Economic Garden, although in the latter station all the varieties were able to produce some heads.

1935–1936 culture.—One culture (Culture J) was conducted in this season in which 10 varieties were tested. The yield of this culture varied from 5,218 to 30,091 kilograms per hectare with Special Succession as the best yielder. The next four best yielders were Surehead, Succession, Enkhuizen Glory and Charleston Wakefield, the corresponding yields of which being 14,291, 13,909, 13,000 and 12,892 kilograms per hectare.

1936–1937 test.—In this culture (Culture L) 14 varieties were studied with four varieties tested for the first time. The stand of the culture was good, the heading ranging from 48 per cent

in the case of Danish Roundhead to 94 per cent in the case of Penn State Ballhead. In size of head, Golden Acre was the smallest, the average weight per head being 0.38 ± 0.027 kilograms. Premium Flat Dutch, Allhead Early and Allhead Select produced the biggest heads, the average weight being 0.84 ± 0.062, 0.83 ± 0.064, and 0.71 ± 0.031 kilograms per head, respectively. Based on yield per hectare, the five best yielders in this culture were Allhead Early, Premium Flat Dutch, Allhead Select, Autumn King, and Enkhuizen Glory. The average yields of these varieties were 19,257, 19,040, 17,230, 15,080 and 15,046 kilograms per hectare, respectively (see Table 9). It will be noted that Succession, one of the best in previous cultures in all stations had only a yield of 14,539 kilograms to the hectare. It may be remarked in this connection that the plots planted to this variety were adjacent to a soybean field and the plants were badly attacked by worms before regular spraying was started.

The results of the Central Experiment Station cultures (Cultures B, C, F, G, J, and L) are summarized in Table 11. Upon examination of this table, it will be seen that 31 varieties have been tested, and two (English) varieties failed to produce heads. The 29 varieties gave average yields ranging from 1,379 to 30,091 kilograms per hectare. The best 10 yielders in their descending order were Special Succession, Allhead Select, Late Flat Dutch, Succession, Shanghai, Autumn King, Stein's Flat Dutch, All Seasons, Charleston Wakefield, and Enkhuizen Glory. It will be noted, however, that varieties Special Succession, Allhead Select, Shanghai, Autumn King, Sein's Flat Dutch, and All Seasons were represented by one culture each; while Late Flat Dutch and Enkhuizen Glory by two tests each; and Succession and Charleston Wakefield by six cultures each.

VARIETIES BEST ADOPTED TO THE DIFFERENT STATIONS

It was rather unfortunate that because of limited facilities it was not possible to test all the varieties and conduct the cultures at the same time in the different stations. With the data here presented it would not be fair to make a comparison of the yields of the different varieties in the different stations. At least, however, the best varieties among those tested in each station may be pointed out for the benefit of gardeners and would-be truckers in the vicinity of those different localities.

Based from one season test, the best for Alabang are Succession and Copenhagen Market (see Table 3). As seen in Table

12, the best cropper under Lipa conditions are Succession, Allhead Early, Charleston Wakefield, Early Jersey Wakefield, and Golden Acre. Under Los Baños conditions, the five best varieties are Premier Flat Dutch, Late Flat Dutch, Surehead, Succession, and Enkhuizen Glory. Charleston Wakefield may be included because of its consistently good performance during three tests (see Table 12).

At the Central Experiment Station, Manila, the five best varieties are Special Succession, Allhead Select, Late Flat Dutch, Succession, and Charleston Wakefield. Special Succession and Allhead Early which were tested for only one season gave average yields of 30,091 and 17,230 kilograms per hectare, respectively. On the other hand, Late Flat Dutch had an average yield of 17,180 kilograms per hectare for two cultures while Succession and Charleston Wakefield gave average yields of 16,513 and 14,078 kilograms per hectare, respectively, for six tests. The range in yield of Succession was from 13,909 to 22,483 kilograms per hectare while the yield of Charleston Wakefield ranged from 9,918 to 16,072 kilograms per hectare.

AVERAGE YIELDS IN ALL STATIONS

As already stated elsewhere, Table 13 presents the average yields of all the varieties tested in the different stations from 1933 to 1937. As shown in Table 13, 33 varieties were tested; 8 varieties were tested in one station only; 17 varieties in two stations; 7 varieties in 3 stations; and 1 variety in 4 stations. Eight varieties were tested only once; 9 varieties, two times; 5 varieties, three times; 3 varieties, four times; 3 varieties, five times; 2 varieties, seven times; 1 variety, nine times, 1 variety, eleven times; and 1 variety, twelve times. It is also seen in Table 13 that the average yields of the different varieties in all the stations where the studies were conducted ranged from 178 to 23,239 kilograms per hectare.

BEST YIELDING VARIETIES

In Table 14 is presented a list of the 15 heaviest yielding varieties found in this study. The average yields of these varieties ranged from 13,102 to 23,239 kilograms per hectare. These varieties in the descending order of their average yields are Special Succession, Succession, Late Flat Dutch, Allhead Early, Allhead Select, Charleston Wakefield, Surehead, Premium Flat Dutch, Shanghai, Enkhuizen Glory, All Seasons, Early Summer, Autumn King, Early Stonehead, and Stein's Flat Dutch.

TABLE 10.—*Average yields per hectare of different cabbage tested at Alabang Rice Station, Lipa Coffee-Citrus Station and Los Baños Economic Garden*

Variety name	Alabang Rice Station	Lipa Coffee-Citrus Station			Los Baños Economic Garden			
	1932–1933	Nov.–Feb., 1933–1934	Jan.–April, 1934	Average	Dec., 1934	Jan., 1935	1935–1936	Average
	Kilo	*Kilo*	*Kilo*	*Kilo*	*Kilo*	*Kilo*	*Kilo*	*Kilo*
Allhead Early		38,578	18,889	28,733			15,345	15,345
Autumn King	12,672							
Charleston Wakefield		25,707	17,022	21,364	18,933	12,256	11 012	14,067
Copenhagen Market	18,816	13,876	11,431	12,653				
Danish Ballhead	6,480						10,303	10,303
Early Jersey Wakefield		17,520	16,320	16,920				
Early Krop		11,929	13,857	12,893				
Early Market	14,896	15,581	14,133	14,857				
Early Summer	14,374							
Early Winnigstadt							6,594	6,594
Enkhuizen Glory							16,436	16,436
Golden Acre		15,129	14,889	15,009	10,633	10,544		10,588
Henderson Premier		13,262	13,324	13,293	9,489			9,489
Late Flat Dutch					24,633	13.178		18,905
Penn State Ballhead							9.473	9,473
Premium Flat Dutch							19,939	19,939
Red Dutch				7.662				
Round Red Dutch							576	576
Special Succession							16,388	16,388
Stein's Flat Dutch	11,400							
Succession	21.470	48,009	22,471	35.240	19,933	13,322	18,412	17,222
Surehead							18.315	18,315
Sutton's Allheart						3,311		3,311
Sutton's Earliest						5,255		5,255
Sutton's Favorite						1,355		1,355
Sutton's Flower of Spring						778		778
Sutton's Maincrop						178		178

TABLE 11.—*Average yields of cabbage varieties tested at the Central Experiment Station, 1933–1937*

Variety name	Dec-Mar, 1933–1934	Feb-Apr., 1934	Oct, 1934	Dec, 1934	1935–1936	1936–1937	Average
	Kilo	*Kilo*	*Kilo*	*Kilo*	*Kilo*	*Kilo*	*Kilo*
Allhead Early	15,562	12,034			5,218	19,257	13,018
Allhead Select						17,230	17,230
All Seasons						14,560	14,560
Autumn King						15,081	15,081
Charleston Wakefield	16,072	15,007	9,918	16,501	12,892	14,080	14,078
Copenhagen Market	9,137	6,119					7,628
Danish Ballhead					6,092		6,092
Danish Roundhead						5,632	5,632
Early Dwarf Flat Dutch			3,457				3,457
Early Jersey Wakefield	9,112	8,119	5,217				7,483
Early Krop	8,048	6,001					7,026
Early Market	5,379	8,563					6,971
Early Stonehead						13,374	13,374
Early Winnigstadt					9,873		9,873
Enkhuizen Glory					13,000	15,046	14,023
Golden Acre	9,379	11,339	6,635	9,837		8,613	9,161
Henderson Premier	7,959	11,523	4,441	9,032			8,239
Late Flat Dutch			19,287	15,074			17,180
Penn State Ballhead					12,200	10,779	11,490
Premium Flat Dutch					7,055	19,040	13,048
Red Dutch	4,685	5,762					5,224
Shanghai			15,102				15 102
Special Succession					30,091		30,091
Stein's Flat Dutch						14,803	14,803
Succession	15,160	18,350	14,635	22,483	13,909	14,539	16 513
Surehead					14,291	13,521	13,906
Sutton's Allheart				6,759			6,759
Sutton's Earliest				5,231			5,231
Sutton's Favorite				1,379			1,379
Sutton's Flower of Spring				(1)			
Sutton's Maincrop				(1)			

[1] The plants did not produce any head in spite of excellent vegetative growth.

TABLE 12.—*Comparative average yields of cabbage in different stations.*

Variety name	Central Experiment Station			Lipa Coffee-Citrus Station			Los Baños Economic Garden		
	Number of tests	Average yield per hectare	Range in yield per hectare	Number of tests	Average yield per hectare	Range in yield per hectare	Number of tests	Average yield per hectare	Range in yield per hectare
		Kilo	*Kilo*	*Kilo*	*Kilo*	*Kilo*	*Kilo*	*Kilo*	*Kilo*
Allhead Early	4	13,018	5,218–19,257	2	28,733	18,889–38,578	1	15,345	15,345
Allhead Select	1	17,230	17,230						
All Seasons	1	14,560	14,560						
Autumn King	1	15,081	15,081						
Charleston Wakefield	6	14,078	9,918–16,072	2	21,364	17,022–25,707	3	14,047	11,012–18,933
Copenhagen Market	2	7,628	6,119– 9,137	2	12,653	11,431–13,876			
Danish Ballhead	1	6,092	6,092				1	10,303	10,303
Danish Roundhead	1	5,632	5,632						
Early Dwarf Flat Dutch	1	3,457	3,457						
Early Jersey Wakefield	3	7,483	5,217– 9,112	2	16,920	16,320–17,520			
Early Krop	2	7,026	6,004– 8,048	2	12,893	11,929–13,857			
Early Market	2	6,971	5,379– 8,563	2	14,857	14,133–15,581			
Early Stonehead	1	13,374	13,374						
Early Summer									
Early Winnigstadt	1	9,873	9,873				1	6,594	6,594
Enkhuizen Glory	2	14,023	13,000–15,046				1	16,436	16,436
Golden Acre	5	9,161	6,635–11,339	2	15,009	14–889–15,129	2	10,588	10,544–10,633
Henderson Premier	4	8,239	4,441–11,523	2	13 293	13–262–13,324	1	9 489	9,489
Late Flat Dutch	2	17,180	15,074–19,287				2	18,905	13 178–24,633
Penn State Ballhead	2	11,490	10,779–12,200				1	9,473	9,473
Premier Flat Dutch	2	13,048	7,055–19,040				1	19,939	19 939
Red Dutch	2	5,224	4,685– 5,762	2	7,662	6,471– 8,853			
Round Red Dutch							1	576	576
Shanghai	1	15,102	15,102						
Special Succession	1	30,091	30,091				1	16,388	16,388
Stein's Flat Dutch	1	14,803	14,803						
Succession	6	16,513	13,909–22,483	2	35,240	22,471–48,009	3	17,222	13,322–19,933

Surehead	2	13,906	13,521–14,291				1	18,315	18,315
Sutton's Allheart	1	6,759	6,759				1	3,311	3,311
Sutton's Earliest	1	5,231	5,231				1	5,255	5,255
Sutton's Favorite	1	1,379	1,379				1	1,355	1,355
Sutton's Flower of Spring	1	(1)					1	778	778
Sutton's Maincrop	1	(1)					1	178	178

[1] These varieties did not produce heads in spite of excellent vegetative growth.

TABLE 13.—*Average yields of cabbage varieties tested in different stations from 1933 to 1937 inclusive*

Variety name	Number of stations where test made	Number of tests made	Average yield per hectare	Range in yield per hectare	Variety name	Number of stations where test made	Number of tests made	Average yield per hectare	Range in yield per hectare
			Kilo	*Kilo*				*Kilo*	*Kilo*
Allhead Early	3	7	17,840	5,218–38,578	Henderson Premier	3	7	9,861	4,441–13,324
Allhead Select	1	1	17,230	17,230	Late Flat Dutch	2	4	18,043	13,178–24,633
All Seasons	1	1	14,560	14,560	Penn State Ballhead	2	3	10,484	9,473–12,200
Autumn King	2	2	13,877	12,672–15,081	Premium Flat Dutch	2	3	15,345	7,055–19,939
Charleston Wakefield	3	11	15,400	9,918–25,707	Red Dutch	2	4	6,443	4,685– 8,853
Copenhagen Market	3	5	11,876	6,119–18,816	Round Red Dutch	1	1	576	576
Danish Ballhead	3	3	7,625	6,092–10,303	Shanghai	1	1	15,102	15,102
Danish Roundhead	1	1	5,632	5,632	Special Succession	2	2	23,239	16,388–30,091
Early Dwarf Flat Dutch	1	1	3,457	3,457	Stein's Flat Dutch	2	2	13,102	11,400–14,803
Early Jersey Wakefield	2	5	11,257	5,217–17,520	Succession	4	12	20,224	13,322–48,009
Early Krop	2	4	9,959	6,004–13,857	Surehead	2	3	15,376	13,521–18,315
Early Market	3	5	11,710	5,379–15,581	Sutton's Allheart	2	2	5,035	3,311– 6,759
Early Stonehead	1	1	13,374	13,374	Sutton's Earliest	2	2	5,243	5,231– 5,255
Early Summer	1	1	14,374	14,374	Sutton's Favorite	2	2	1,367	1,355– 1,379
Early Winnigstadt	2	2	8,233	6,594– 9,873	Sutton's Flower of Spring	2	2	778	0– 778
Enkhuizen Glory	2	3	14,827	13,000–16,436	Sutton's Maincrop	2	2	178	0– 178
Golden Acre	3	9	10,778	6,635–15,129					

TABLE 14.—*Showing the average yield per hectare of the fifteen highest yielding cabbage varieties*

Variety name	Number of stations where tests made	Number of tests made	Average yield per hectare	Range in yield per hectare
			Kilos	*Kilos*
Special Succession	2	2	23,239	16,388–30,091
Succession	4	12	20,224	13,322–48,009
Late Flat Dutch	2	4	18,043	13,178–24,633
Allhead Early	3	7	17,840	5,218–38,578
Allhead Select	1	1	17,230	17,230
Charleston Wakefield	3	11	15,400	9,918–25,707
Surehead	2	3	15,376	13,521–18,315
Premium Flat Dutch	2	3	15,345	7,055–19,939
Shanghai	1	1	15,102	15,102
Enkhuizen Glory	2	3	14,827	13,000–16,436
All Seasons	1	1	14,560	14,560
Early Summer	1	1	14,374	14,374
Autumn King	2	2	13,877	12,672–15,081
Early Stonehead	1	1	13,374	13,374
Stein's Flat Dutch	2	2	13,102	11,400–14,803

Special Succession.—This variety gave the highest average yield based on two tests in two stations, Central Experiment Station and the Los Baños Economic Garden. The yield ranged from 16,388 to 39,091 kilograms per hectare giving an average of 23,239 kilograms. This variety is very similar to Succession (Plate 2), medium early and a sure cropper. The head is solid, but the core is generally long.

Succession.—One of the best among those tested. It has an average yield of 20,224 kilograms per hectare based on 12 cultures in 4 stations; the range in yield was from 13,322 to 48,009 kilograms per hectare. This variety is medium early, maturing in 80 to 120 days depending upon the season. The head is comparatively solid (Plate 3). It has a very wide range of adaptability, and has been found to be good as a main crop as well as for early and late planting.

Late Flat Dutch.—A heavy yielder but rather late, about two weeks later than Succession. The plant is characterized by numerous spreading leaves. Specially adopted for main cropping during the cool months of the year. It has a computed average yield of 18,043 kilograms per hectare; the range in yield was from 13,178 to 24,633 kilograms per hectare.

Allhead Early.—This variety was tested seven times in 3 stations and gave an average yield of 17,840 kilograms per

hectare; the range in yield was from 5,218 to 38,578 kilograms. The head is medium to large and is fairly compact (Plate 4). Medium late and is a good cropper.

Allhead Select.—This was cultured only once and it has shown great promises for lowland culture as compared with Succession and Allhead Early. The head is compact and has neat appearance (Plate 5).

Charleston Wakefield.—This variety was credited with 15,400 kilograms per hectare as average of 11 cultures conducted in 3 different stations. The range in yield was from 9,918 to 20,707 kilograms per hectare. Medium early and is a constant producer. This is the best yielder among the heart-shaped varieties (Plate 6).

Surehead.—Tested three times in 2 stations with production ranging from 13,521 to 18,315 kilograms per hectare. The average of the three tests was 14,376 kilograms per hectare. This is a sure cropper with heads of medium size that are fairly compact (Plate 7).

Premium Flat Dutch.—This variety has been tested three times in 2 stations. The plant is big and rather leafy. Its average yield was 15,345 kilograms per hectare and the range was from 7,055 to 19,939 kilograms. The head is big but rather spongy. A heavy cropper when planted during the cool months. It matures in about 1½ to 2 weeks later than Succession.

Shanghai.—Tested only once and at the Central Experiment Station. This variety is commonly grown in Baguio and Trinidad Valley during the rainy months because of its pronounced ability to withstand wet conditions of weather and its fair resistance to diseases (1933). A very late variety maturing in 150 to 170 days. At the Central Experiment Station, the average weight of a head was 1.3 kilograms. The percentage heading was only 43 per cent, hence the computed yield per hectare was only 15,102 kilograms. The head is big but generally not solid, coarse and has a very strong cabbage odor.

Enkhuizen Glory.—Has been cultured three times in two stations. It gave an average yield of 14,827 kilograms a hectare, and the range of its yield was from 13,000 to 16,436 kilograms. A very good variety for commercial planting because of its medium sized-heads that are very solid (Plate 9). A medium early maturing variety.

All Seasons.—Has been tested once at the Central Experiment Station. Its average yield was 14,560 kilograms per hectare. A promising variety.

Early Summer.—This variety was tested once and it gave an average yield of 14,374 kilograms a hectare. Rather leafy with medium sized-heads, and matures about a week later than Succession.

Autumn King.—This has been tested two times in 2 stations. Its yield varied from 12,672 to 15,081 kilograms per hectare with an average of 13,877 kilograms. This variety is promising and is included among those for further testing. The eating quality is good and the core is small in proportion to the head (Plate 10).

Early Stonehead.—This is one of the latest varieties tested that was found promising. The yield was only 13,374 kilograms to the hectare, but its quality was very good, and the appearance of the head very inviting. The head is solid, with very little core (Plate 11).

Stein's Flat Dutch.—This was cultured once in 2 stations with yield ranging from 11,400 to 14,803 kilograms. Its average yield was 13,102 kilograms per hectare. A medium early maturing variety with heads of medium size and fairly compact (Plate 12).

Other varieties that are worth mentioning although not among the 15 best yielders are Golden Acre, Henderson Premier, and Early Market. These are early varieties maturing in 60 to 70 days with small-sized heads that are solid and of excellent eating qualities. They are very good for home gardens. The plants are small with few loose leaves and therefore could be planted closer together.

SUMMARY AND CONCLUSIONS

This paper embraces a study covering a period of five years, 1932–1937, inclusive. A total of 33 varieties has been tested: 8 varieties tested in one station; 17 in two stations; 7 in three stations; and 1 variety in four stations. Eight varieties were tested once only; 9 varieties two times, 5 three times, 3 four times, 3 five times, 2 seven times, 1 nine times, 1 eleven times, and another variety for twelve times.

Of the 33 varieties tested, 15 gave average yields ranging from 14,827 to 23,239 kilograms per hectare, namely Special

Succession, Succession, Late Flat Dutch, Allhead Early, Allhead Select, Charleston Wakefield, Surehead, Premium Flat Dutch, Shanghai and Enkhuizen Glory. The corresponding average yields of these varieties were 23,239, 20,224, 18,043, 17,840, 17,230, 15,400, 15,376, 15,102, and 14,827 kilograms per hectare.

While not all the varieties in this study were tested in the different stations, from the results thus far obtained it was evident that the varieties found best yielders in one station were not necessarily the best in other stations as will be shown later. Nevertheless, there were a few varieties that were included among the best in all stations like Succession.

At the Alabang Rice Station, the best varieties were Succession, Copenhagen Market, and Early Market. Their corresponding yields were 21,470, 18,816 and 14,896 kilograms per hectare. These varieties matured from 80 to 106 days and had a heading of from 97 to 98 per cent.

Out of 19 varieties tested at the Los Baños Economic Garden, Los Baños, Laguna, the five best yielding varieties as a result of three tests were Premium Flat Dutch, Late Flat Dutch, Surehead, Succession and Enkhuizen Glory. Their corresponding average yields were 19,939, 18,905, 18,315, 17,222 and 16,431 kilograms per hectare.

The heaviest yielding varieties found at the Lipa Coffee-Citrus Station out of 10 varieties tested were Succession, Allhead Early, Charleston Wakefield, Early Jersey Wakefield and Golden Acre. The average yields of these varieties were 35,240, 28,733, 21,364, 16,920 and 15,009 kilograms per hectare, respectively.

At the Central Experiment Station, Manila, where 31 varieties were tested from one to six times, the best varieties with respect to yield per unit area were Special Succession, Late Flat Dutch, Succession, Autumn King and Charleston Wakefield. The corresponding yields of these varieties were 30,091, 17,180, 16,513, 15,081 and 14,078 kilograms per hectare.

In some stations like the Los Baños Economic Garden and the Lipa Coffee-Citrus Station, the varieties found best for early planting were as a rule, the best for late planting. In Lipa, the best yielders in the 1933–1934 vegetable season were Succession, Allhead Early, Charleston Wakefield and Early Jersey Wakefield in both the early and late planting (see Table 3).

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ILLUSTRATIONS

PLATE 1

Acclimatization plots at the Lipa Coffee-Citrus Station, Lipa, Batangas. The plots were protected by improvised windbreak made of coconut leaves.

PLATE 2

Special Succession cabbage: *1*, A typical plant with head; *2*, head, side view; *3*, head, top view; *4*, head, longitudinal section; and *5*, head, cross-section. Note the rather long core in *4*.

PLATE 3

Succession cabbage: *1*, A typical plant with head; *2*, head, top view; *3*, head, cross-section; *4*, head, longitudinal section; and *5*, head, lateral view. Note the compact head in *4*, and the rather long core.

PLATE 4

Allhead Early cabbage: *1*, A typical plant with head; *2*, head, lateral view; *3*, head; top view; *4*, head, longitudinal section; and *5*, head, cross-section. Note the rather long core and the comparative uniform compactness of the head.

PLATE 5

Allhead Select cabbage: *1*, A typical plant with head; *2*, head, lateral view; *3*, head, top view; *4*, head, longitudinal section showing the compact nature on top and the rather loose lower portion; and *5*, head, cross-section.

PLATE 6

Charleston Wakefield cabbage: *1*, A typical plant with head; *2*, head, lateral view; *3*, head, top view; *4*, head, longitudinal section; and *5*, head, cross-section. Note the pointed head as seen in *2*, and *4*, and its compactness as seen in *4* and *5*.

PLATE 7

Surehead cabbage: *1*, A typical plant with head; *2*, head, top view; *3*, head, cross-section; *4*, head, side view; and *5*, head, longitudinal section. Note the compact nature at the upper portion, and the looseness of the lower portion.

PLATE 8

Premium Flat Dutch cabbage: *1*, A typical plant with head; *2*, head, longitudinal section; *3*, head, side view; *4*, head, cross-section; and *5*, head, top view.

PLATE 9

Enkhuizen Glory cabbage: *1*, A typical plant with head; *2*, head, side view; *3*, head, top view; *4*, head, longitudinal section of head; and *5*, head, cross-section. Note the very compact nature of the head in *4* and *5*.

PLATE 10

Autumn King cabbage; *1*, A typical plant with head; *2*, head, side view; *3*, head, top view; *4*, head, longitudinal section; and *5*, head, cross-section. Note the short core in *4*.

PLATE 11

Early Stonehead cabbage: *1*, A typical plant with head; *2*, head, side view; *3*, top view of head; *4*, longitudinal section of head; and *5*, head, cross-section. Note the small-sized core in *5*.

PLATE 12

Stein's Flat Dutch cabbage: *1*, A typical plant with head; *2*, head, lateral view; *3*, head, top view; *4*, head, longitudinal section; and *5*, head, cross-section. Note the long core in *4*.

PLATE 13

Early Winnigstadt cabbage: *1*, A typical plant with head; *2*, head, lateral view; *3*, head, cross-section; *4*, head, longitudinal section; and *5*, top view. Note the long core and looseness of the head in *4*.

PLATE 14

Danish Ballhead cabbage: *1*, A typical plant with head; *2*, head, lateral view; *3*, head, top view; *4*, head, longitudinal section; and *5*, head, cross-section.

PLATE 1.

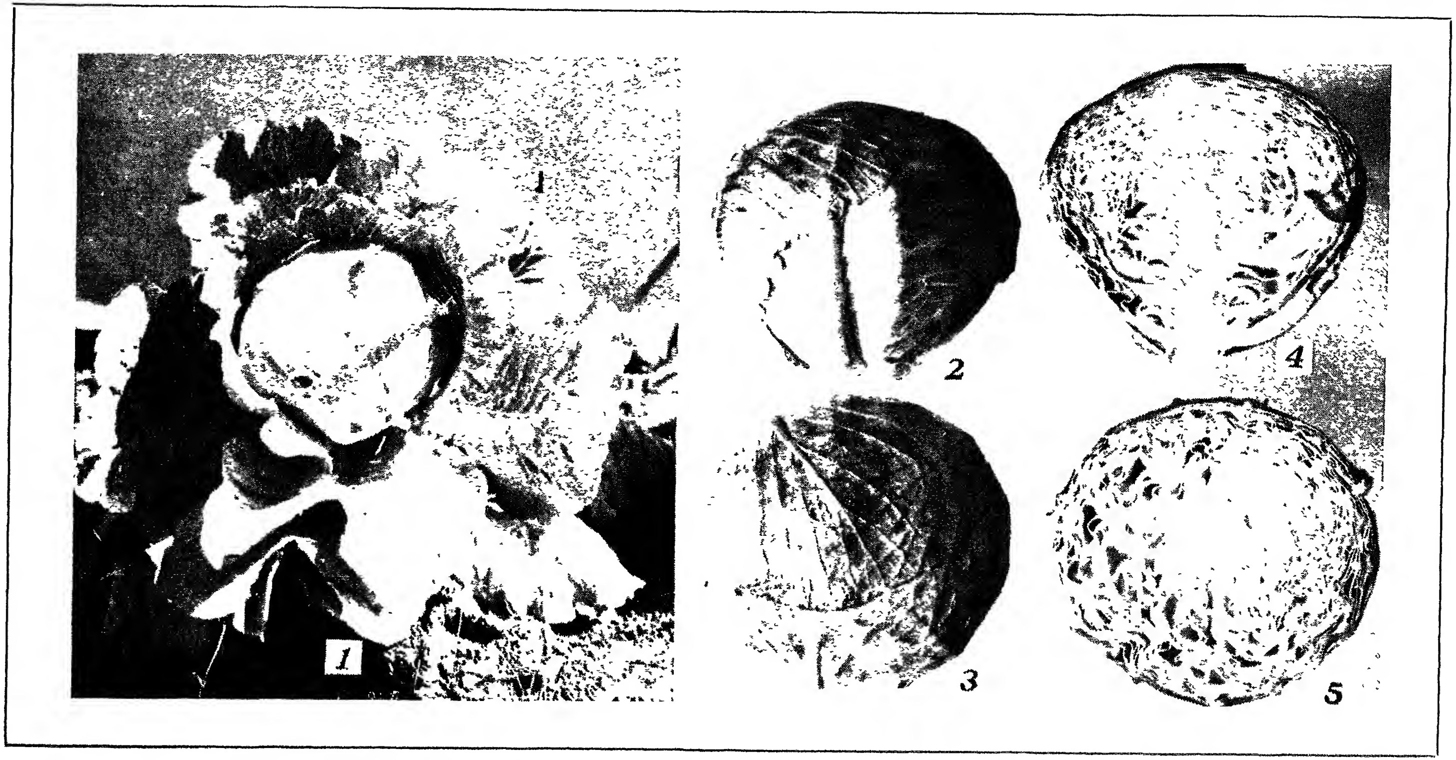
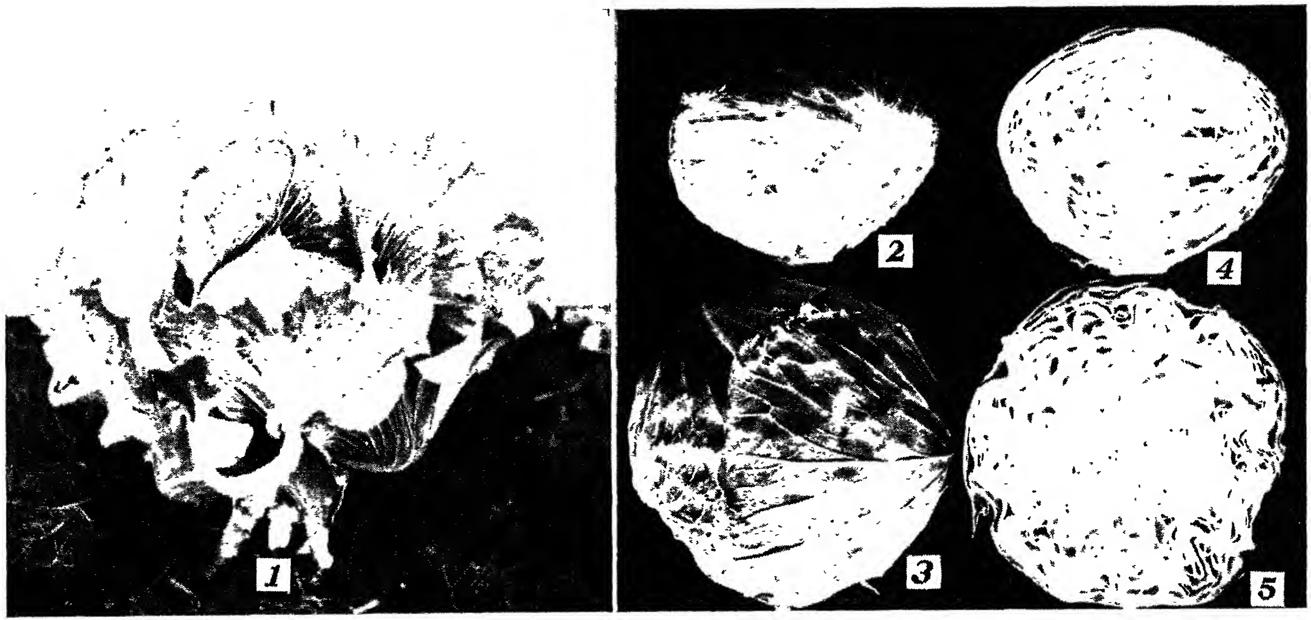


PLATE 2.

PLATE 3.



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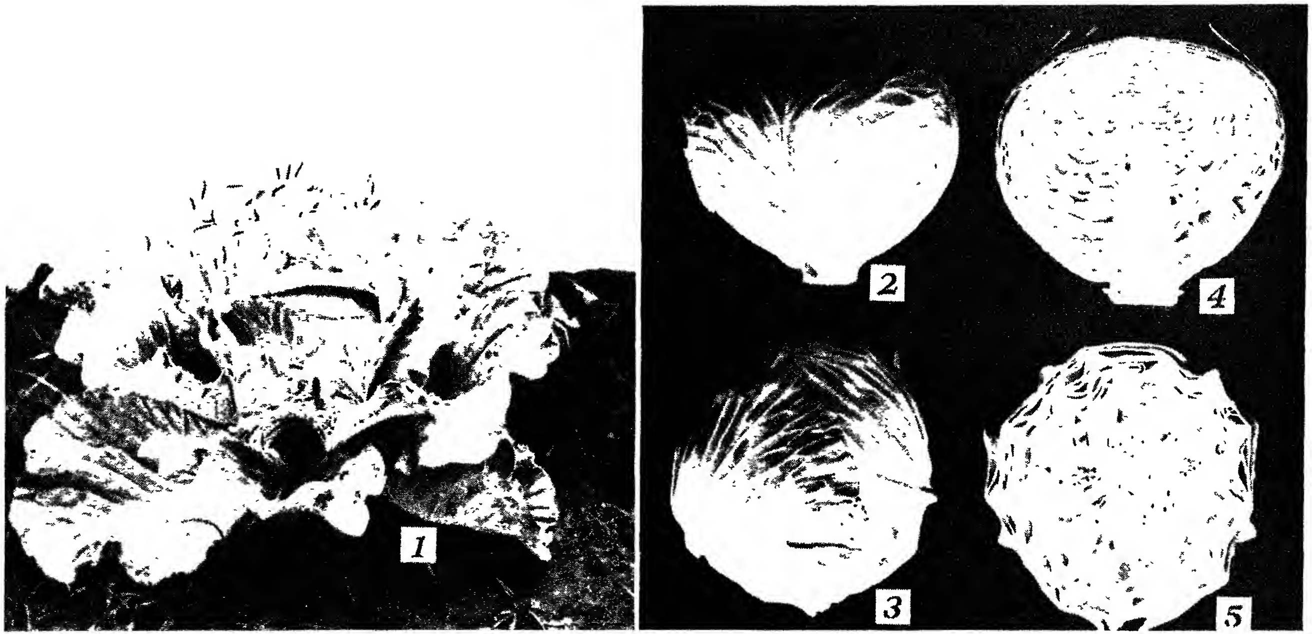

PLATE 5.

PLATE 6.

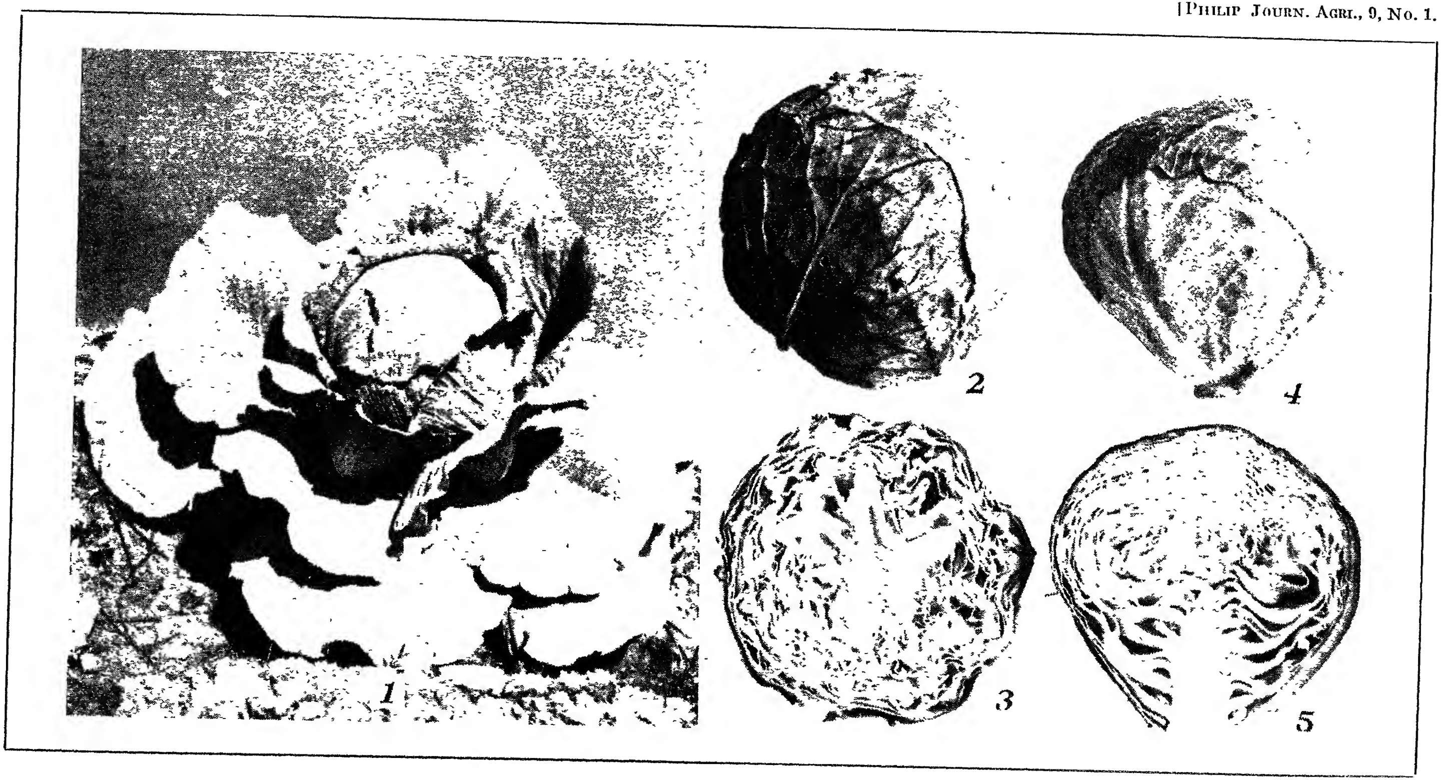

PLATE 7.

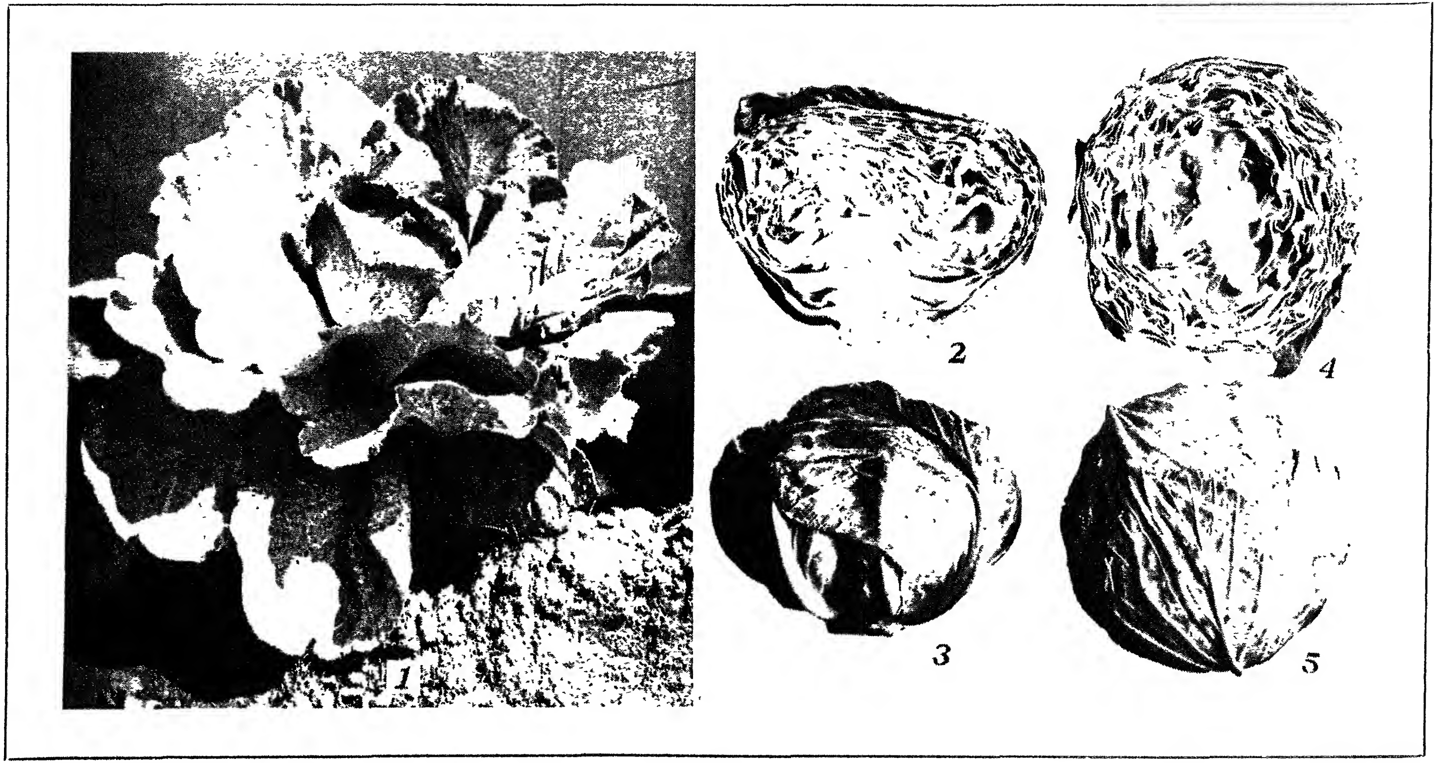

PLATE 8.

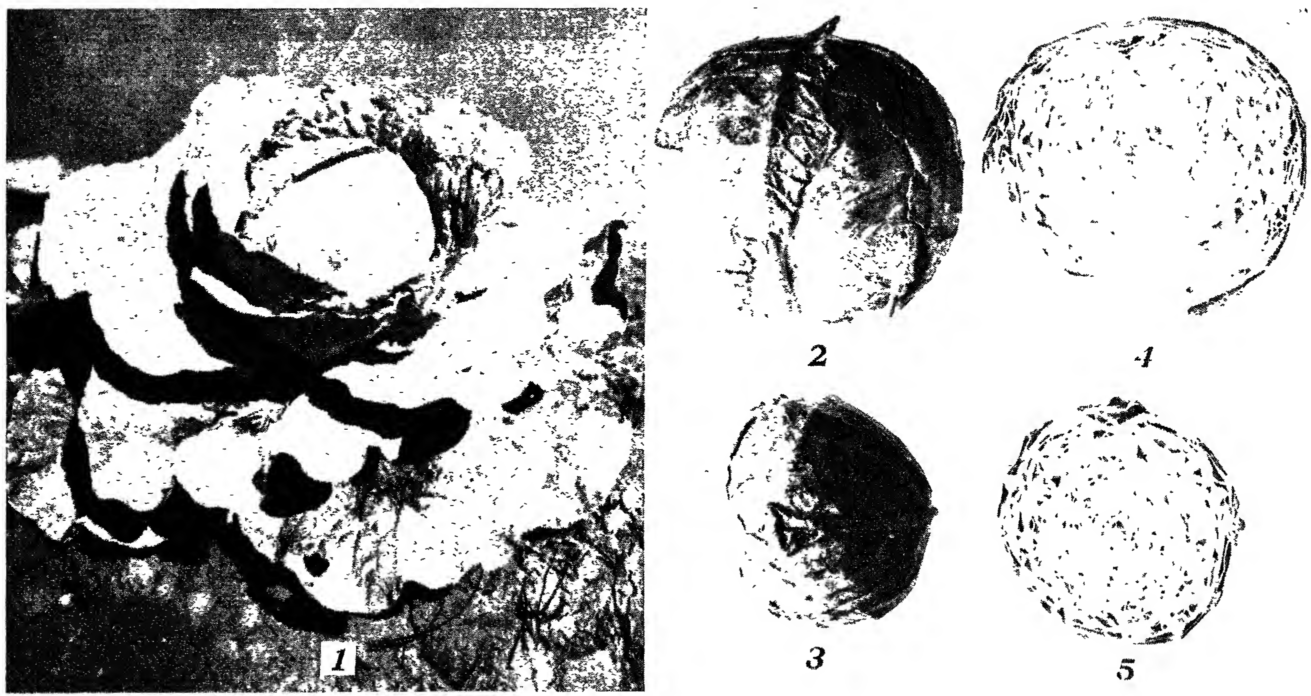

PLATE 9.

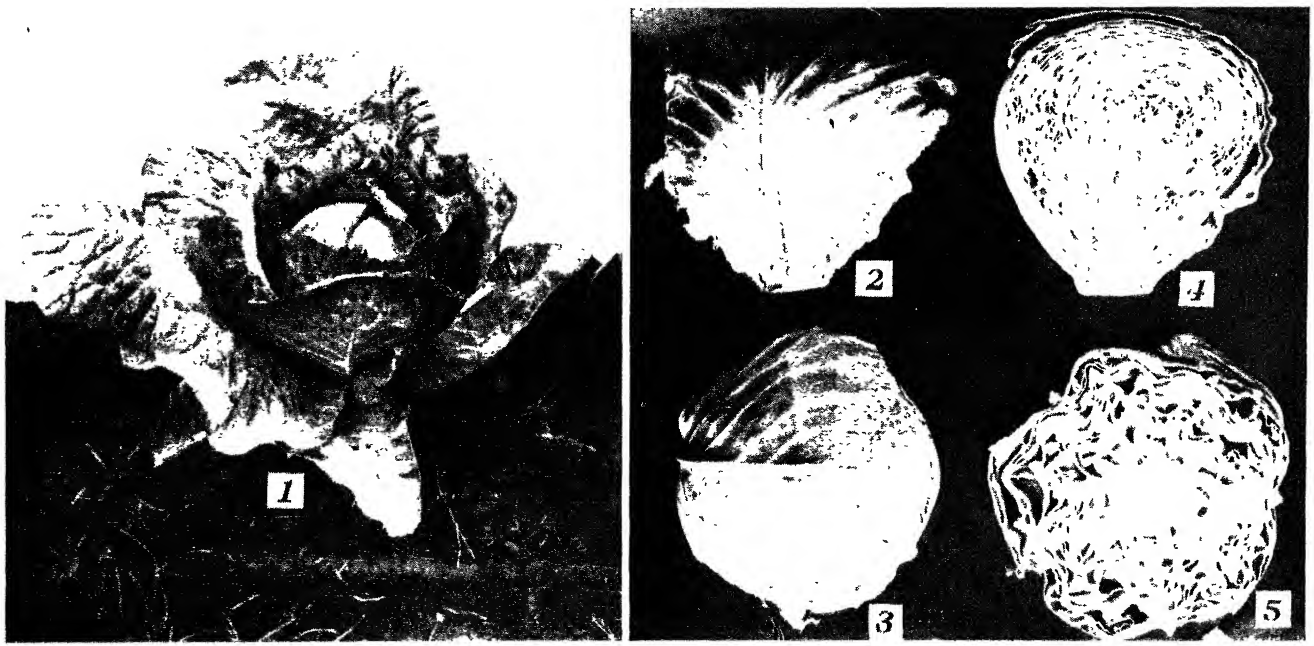

PLATE 10.

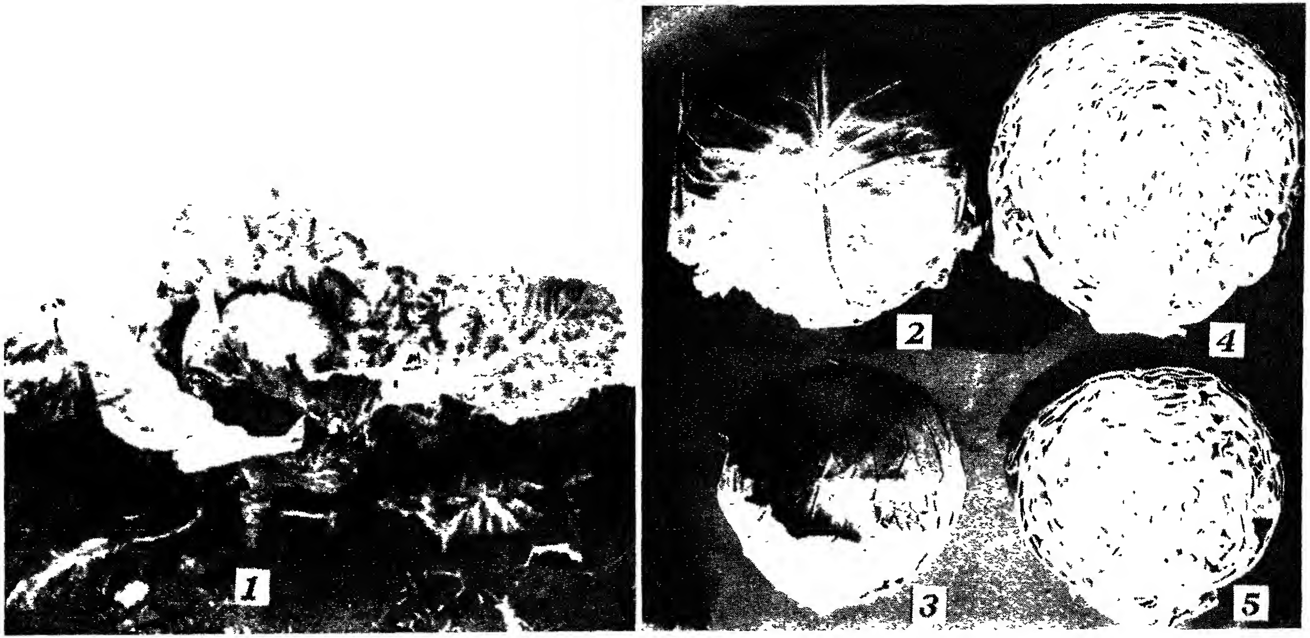

PLATE 11.

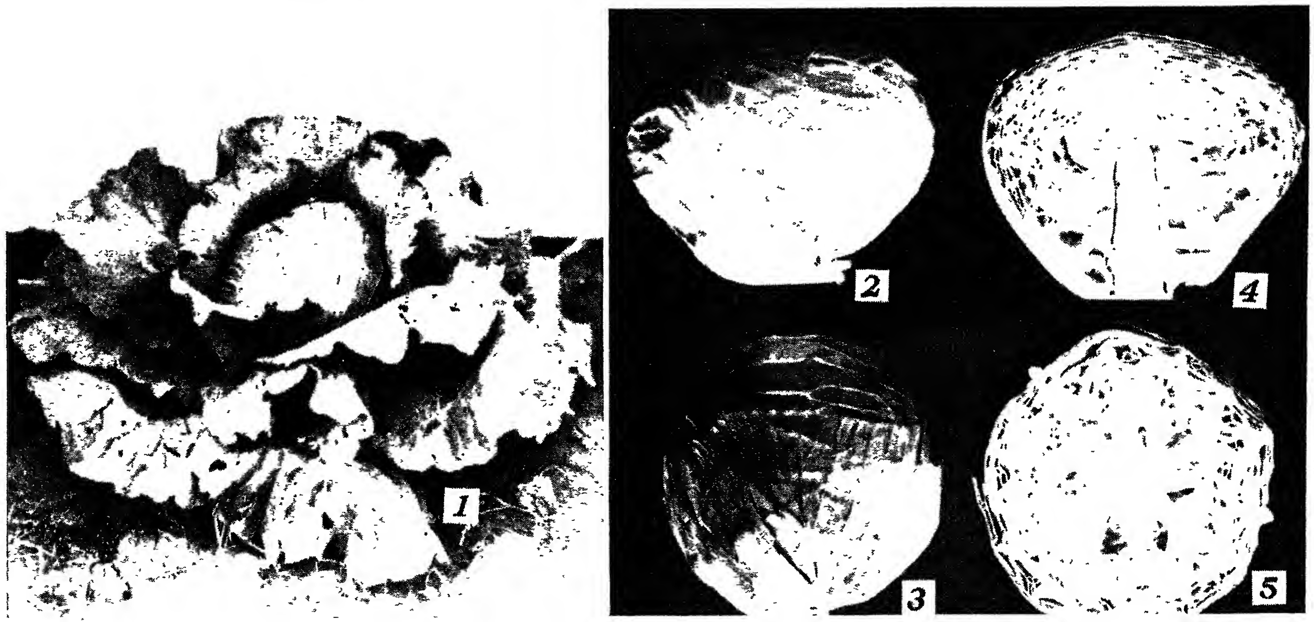

PLATE 12.

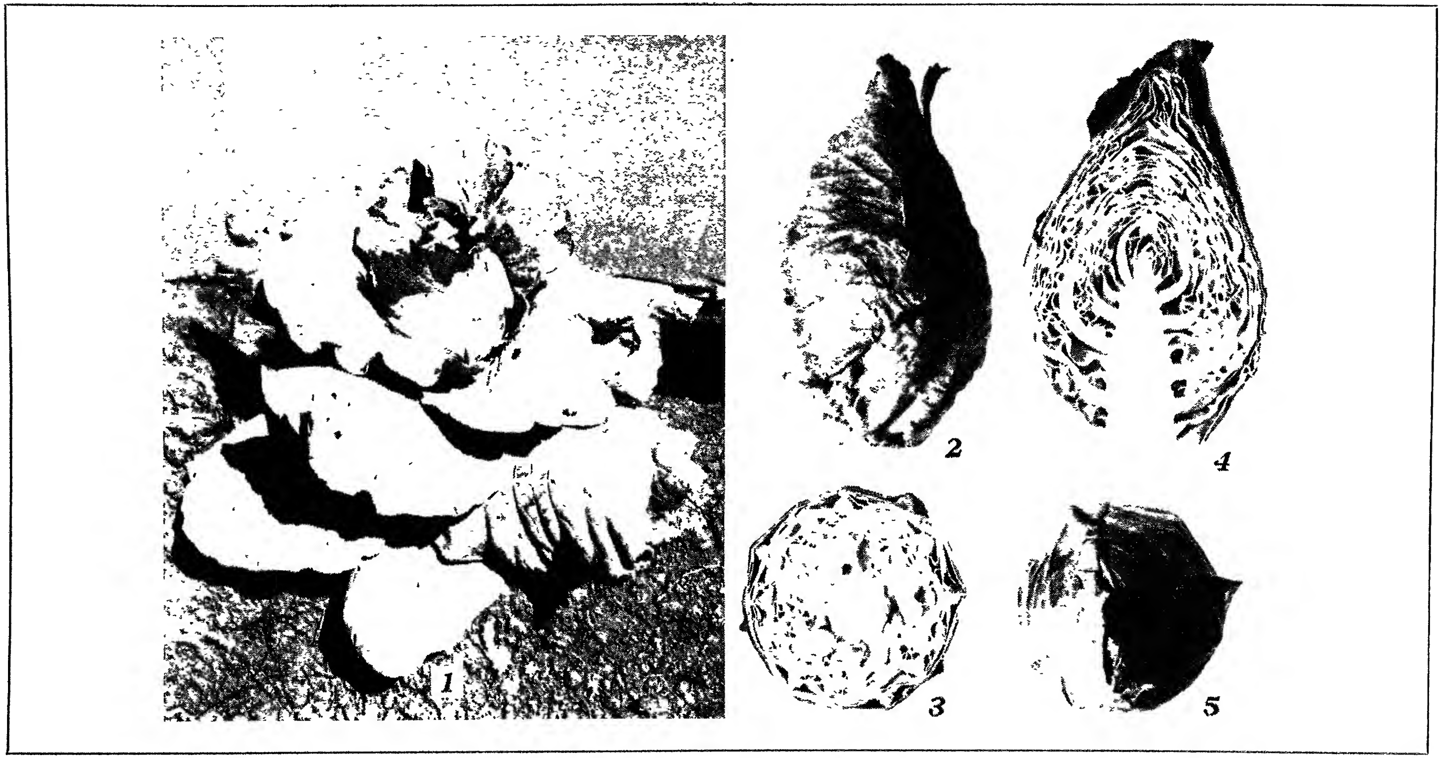

PLATE 13.

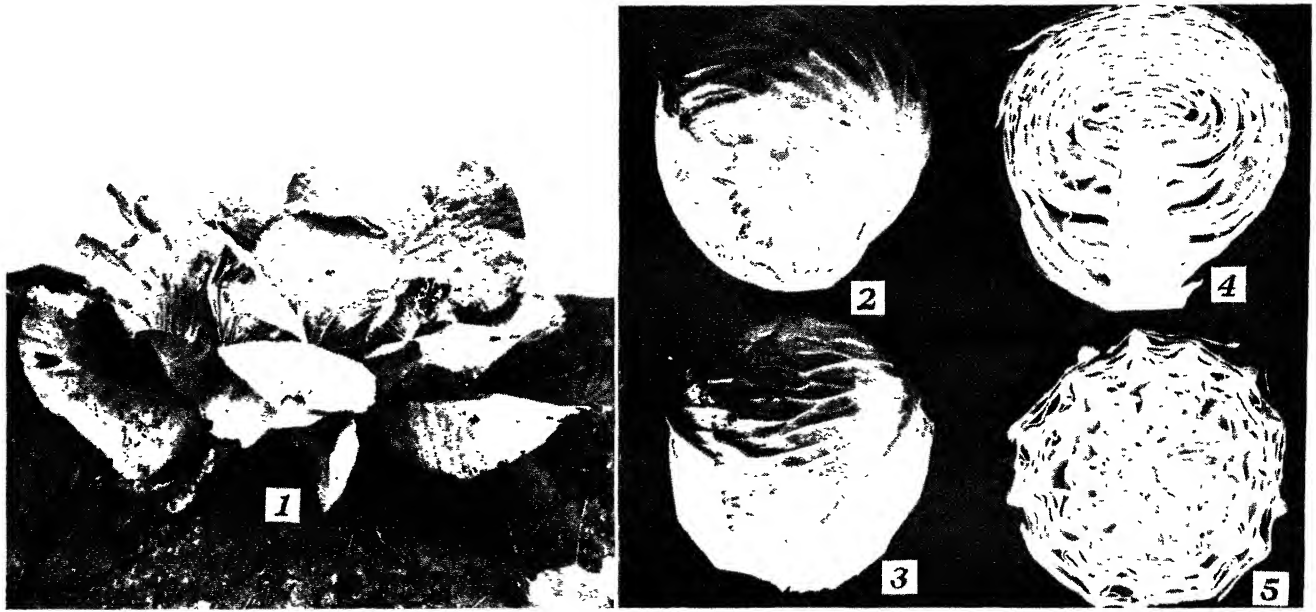

PLATE 14.

A REPORT ON THE PRESENCE OF THE COCONUT ZYGAENID, ARTONA CATOXANTHA HAMPS, IN THE PROVINCE OF PALAWAN

By GONZALO MERINO
Of the Bureau of Plant Industry

ONE PLATE

The coconut zygaenid moth, *Artona catoxantha*, Hamps, of the family Zygaenidæ, a very destructive pest of coconut heretofore not reported in the Philippines, has been found to infest coconut groves in Palawan.

The first report about this pest was received early in 1927. The groves infested being located in Iwahig Penal Colony, Puerto Princesa, that is, in the middle section of the island of Palawan. This infestation was immediately placed under control by having the infested fronds cut and burned. In 1931, however, the pest reappeared in the same place and similar control measure was adopted. Simultaneously the pest appeared in the barrio of Tandayag, about 20 miles away from Iwahig Penal Colony, Puerto Princesa, in the coconut groves of Messrs. Manalo and Fernandez. Since then the owners and the tenants, under the direction of the plant inspectors of the Bureau of Plant Industry, have been fighting it by spraying the leaves with calcium arsenate solution and burning the fronds. When the writer visited the infestations at Tandayag and Maruyogon about the middle of March of 1937, the insects were fast emerging from the pupal cases. Burning of the infested fronds was still being employed. Fortunately two days after, there was quite a strong gale followed by torrential rains within the areas infested. These adverse weather conditions apparently caused a high mortality, that up to this time no further recurrence of the pest in those localities has been reported.

The range of infestation during the inspection trip of the writer was on the coast line from the barrio of Tandayag to the sitio of Maruyogon on a strip of land about three-fourth of a kilometer wide and 8 to 10 kilometers long, infesting over

10,000 trees of the 27,000 coconut trees in a solid grove of Messrs. Manalo and Fernandez, and about 2,000 other trees on irregularly planted groves on the sea coast up to Maruyogon, the opposite sides of the plantations are forested areas.

On his return to Manila, the writer sent specimens of the adult moth and larvæ to Dr. P. Van der Goot, Institute of Plant Disease, Buitenzorg, Java, for verification. Dr. Van der Goot, confirmed our identification of the insect as *Artona catoxantha*, Hamps.

DESCRIPTION OF THE INSECT AND MODE OF ATTACK

The adult moth is dark-brown or almost black in color above. It has a wing expanse of about 15 millimeters, the tips of the wings are fringed and light yellow ventrally, including the legs. The caterpillar is slug-like because of the rows of glandular hairs on the dorsal segment of the larva. When newly hatched, it is palish green and somewhat translucent. As it becomes older the color changes to greenish-yellow with dirty brownish-black stripe on the middle dorsal and with irregular marking on the marginal side of the same. Fully-grown larvæ attain the length of about 10 millimeters. It is the larva that causes injury on the under side epidermis of the leaflet, by eating longitudinal transparent slits, causing the entire frond to turn brown and dry up. The attack is generally found on the mature fronds which causes them to fall. Thus the immature nuts also fall off causing great losses to the coconut planters because of reduced crop harvested and because of delayed production. It is true that the coconut trees are not killed, but the health of the infested trees is greatly affected and the losses of immature nuts are very evident.

The eggs are laid singly on the under side of the pinnæ in irregular batches slightly oval almost cylindrical in form but flattened, about ½ of a millimeter in length, the cocoon are spun by the larvæ mostly on the under side of the coconut leaflets. Many cocoons were found on the side of the stem of the fronds. They are white, flat and elliptical in shape about 10 to 11 millimeters long and about 5 to 6 millimeters wide.

The pupa is pale green to light yellow, about 7 millimeters in length, becoming darker as it gets older and more so before the moth emerges, when it assumes the color of the adult moth.

HABITS AND ECONOMIC IMPORTANCE

This insect is considered by Dammerman [1] as a destructive pest of coconut and is known in the Malay Peninsula as "ulat hantu kail" or "ulat gantong." Because of their feedings, the larvæ cause longitudinal patches on the under side of the pinnæ which have the characteristic of batches similar to the attack of the adult coconut leaf miner and some slug caterpillars, only they are wider, as illustrated herewith. The attack starts on mature fronds beginning from the outer most frond to the younger ones. When the attack is quite severe the infestation reaches even the youngest fronds. The attacked fronds wither quickly and later hang or droop down. Then the falling of immature nuts follow. In many cases, the dropping of the young-nuts become total causing a severe setback to the production of the trees and impairing the health of these considerably. There has been, however, no cases of trees killed from the attack, but it is presumed, that severely attacked trees may not produce normally until after two years.

The adult insects become sexually mature one day after emergence as evidenced by their copulating propensities after that time. They fly around in the open and alight on any hanging leaves or objects on a semi-erect posture as shown in plate 1(*d*). During such infestation, it was observed that they are not attracted to Dietz lamps placed out in the open at night, neither were they observed to approach bonfires built in an open copra dryer.

RANGE OF DISTRIBUTION

This insect has never been mentioned in any literature at present in the Philippines. I am now, therefore placing the Province of Palawan within the range of distribution of this pest. According to Tothil *et al.*[2] the range of distribution are as follows: Malaya, Sumatra, Java, Borneo, Labuan, and Tenasserim. It is possible that Palawan Island is within the distributional center. According to Dickerson *et al.*,[3] Palawan and

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[1] Dammerman, W. K. Agric. Zoö. of the Malay Archipelago, p. 149.

[2] The coconut moth in Fiji, Imperial Bureau of Entomology, p. 211; 1936.

[3] Distribution of life in the Philippines, Bureau of Printing pp. 24–25, 28, p. 265.

its dependent islands, that is, the Calamianes, are in the oriental region under the Arctogaeic realm to which region Palawan and the Calamianes with the southern peninsula of Asia, Malay Archipelago including Sunda Islands belong. It is said by the same authors that probably at the period when the Philippines were isolated from the rest of the Malay region, Celebes, Java, Sumatra, Borneo, and Palawan were still connected with each other. For this particular reason the coconut Zygaenid moth, *Artona catoxantha* Hamps may be indigenous or autochthonous to Palawan also. The possibilities of accidental introduction are very remote. In the first place, it could not have been introduced by men as there are no coconut plants ever imported for planting nor for ornamental purposes. Such things are not done, only the coconut seeds being introduced. Neither could it have been blown by wind from North Borneo to the mainland of Palawan as the big infestations became known in the middle section of the island of Palawan instead of the southern extremities.

REPORTED HOST PLANTS

Dammerman (Agric. Zoöl. of the Malay Archipelago, pp. 149-150-(1929), mentions that the coconut Zygaenid moth also attacks other palms such as *Nipa*, Nibong (*Oncosperma*), sago palm, *Areca* and *Calamus*. Tothil *et al.* (the coconut moth in Fiji, p. 211; 1930), gives the following food plants:—*Cocos, Metroxylon, Areca, Phœnix, Oncosperna, Calamus, Nipa.*

NATURAL ENEMIES

The most dominant natural enemies of *Artona catoxantha* in Malaya is a Tachinid parasitic insect, *Ptychomyia remota*. This beneficial insect was once used with success to control the Fiji coconut moth, *Levuana irridescens* which broke out in Fiji Islands early in 1925. Corbett in his Insects of Coconuts of Malaya, pp. 81–82, names another Tachinid fly, *Degeeria albiceps;* two Icheneumonids, *Goryphus maculiceps*, and *G. maculipennis;* a Braconid, *Apanteles artona;* a predator Clerid beetle, *Calimerus areufer* and an entomophagous fungus, *Botrytis necans*. Dammerman (pp. 149–150) gives the following additional natural enemies: A predatory Pentatomid bug, *Canthecona furcellata;* A Braconid, *Microgaster* sp.; An Ichneumonid—*Mesostenus* sp. Tothil *et al.* (p. 213) also mentions, *Euplectrus* sp. an *eulophid* parasite.

With the preserved larvæ I brought from the field, I noticed cocoons of *Apanteles* attached to the ventral side of many of my larval specimens.

CONTROL MEASURES

The control measures applied against the Palawan infestations were burning of the larval and pupal infested leaves, and the spraying with soap and calcium arsenate solutions on the larvæ infested leaves as contact and stomach insecticides, respectively. The complete disappearance of the moths apparently was effected by coincidence of infestations in the adult stage with occurrence of strong winds and torrential rains during the month of March of this year (1937).

ILLUSTRATION

PLATE 1

Fig. 1. *Artona catoxantha* Hamps, male enlarged (wing expanse of specimen about 14 mm.).

2. *Artona catoxantha,* with wings folded (length of specimen from tip of head to tip of wing about 7 mm.).
3. Egg. (length of specimen about 0.5 millimeter).
4. Characteristic attitude of moths.
5. Empty cocoons (length of a cocoon about 11 millimeters).
6. Caterpillar (length about 10 milimeters).
7. Pupa. (length about 7 millimeters).
8. Portion of a coconut leaflet showing injury by caterpillars.

[NOTE.—Figures 1, 3, 4, 5, 6, and 7 were drawn from Corbetts Insects of Coconuts in Malaya, 1932, while figures 2 and 8 are original.]

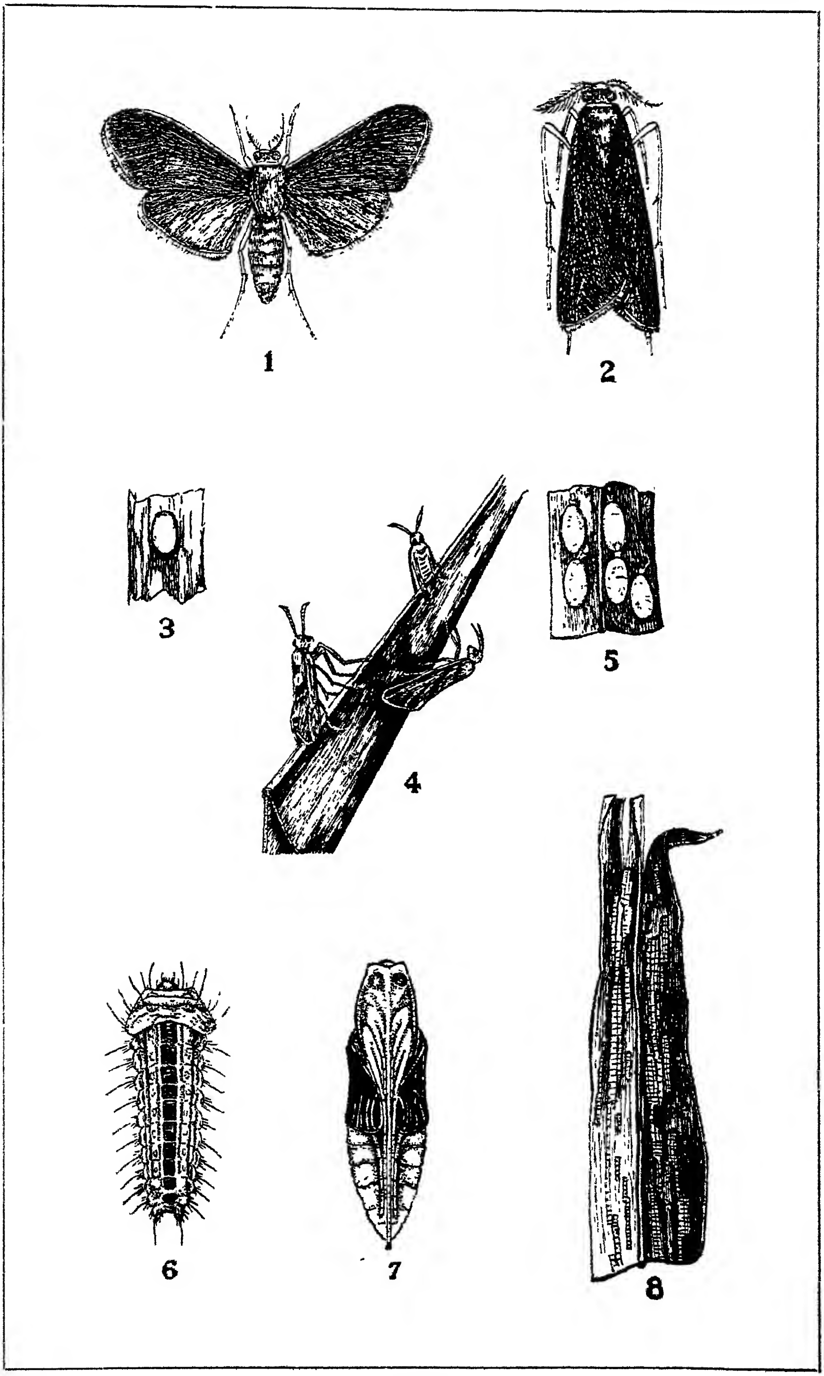

PLATE 1.

NOTES ON THE PROPAGATION OF *LONCHOCARPUS NICOU* (AUBL.) DC. BY MARCOTTAGE

By NICANOR G. TEODORO

and

FILEMON Q. ABAYA

Of the Bureau of Plant Industry

TWO PLATES

On September 22, 1932, six rooted cuttings of "Cube" of Peru, botanically known as *Lonchocarpus nicou* (Aubl.) DC. and belonging to the Leguminosae family, were received at the Economic Garden, Los Baños, Laguna, from the Bureau of Plant Industry of the U. S. Department of Agriculture, Washington, D. C. It may be mentioned in this connection that this plant is a shrub or small tree supposed to be superior to *Derris* as a source of rotenone, a substance of value as an insecticide.

These cuttings were planted first in the nursery where they were observed not to thrive well. In fact two of them died. The four that survived were later potted to insure a better care.

On January 29, 1934, or a year after potting, believing that they were already safe for transplanting, they were set in the Leguminosæ section within the Systematic Field. After some time, however, only two plants remained alive.

It was thought necessary to multiply the surviving plants, and realizing that they are delicate, the writers have resorted to marcotting a branch from one of the mother plants which has attained a height of about 1.2 meters. In the marcotting operation the junior writer made the following process:

On April 28, 1937, the branch selected for the purpose was girdled at a convenient point to about 2 centimeters in length as indicated in Plate 1, fig. 1. The bark of the girdled section was removed and the cambium layer scrapped off with a budding knife, the purpose being to prevent the wound from healing during the callousing period.

On May 27, 1937, or about a month after the removal of the bark, when the wound has calloused, coconut fiber containing equal parts of ordinary garden soil and horse manure, was tied

around and over the debarked portion as shown in Plate 1. Just above this point there were tied two tin cans (Plate 2, fig. 1), having tiny perforations at the bottom, which were constantly filled with water whenever necessary, the purpose being to keep moist the medium for rooting.

On July 5, 1937, some roots were observed penetrating through the coconut fiber, and 8 days thereafter when sufficient number of roots (Plate 2, fig. 1) were formed, the branch was cut, as usual for any marcotted branches, and planted in a big earthen pot (Plate 2, fig. 2). The rooting medium was not removed but allowed to remain with the potted plant. This plant is kept in the nursery shed for a few weeks, or until it has a thoroughly established root system.

ILLUSTRATIONS

PLATE 1

A 4-year old *Lonchocarpus nicou* (Aubl) DC. showing (1) two branches, one of which (left) was marcotted, (2) a close-up view of the marcotted branches.

PLATE 2

The same plant showing (1) the marcotted branch severed from the mother plant, (2) the same branch planted in an earthen pot to insure better care, etc.

PLATE 1.

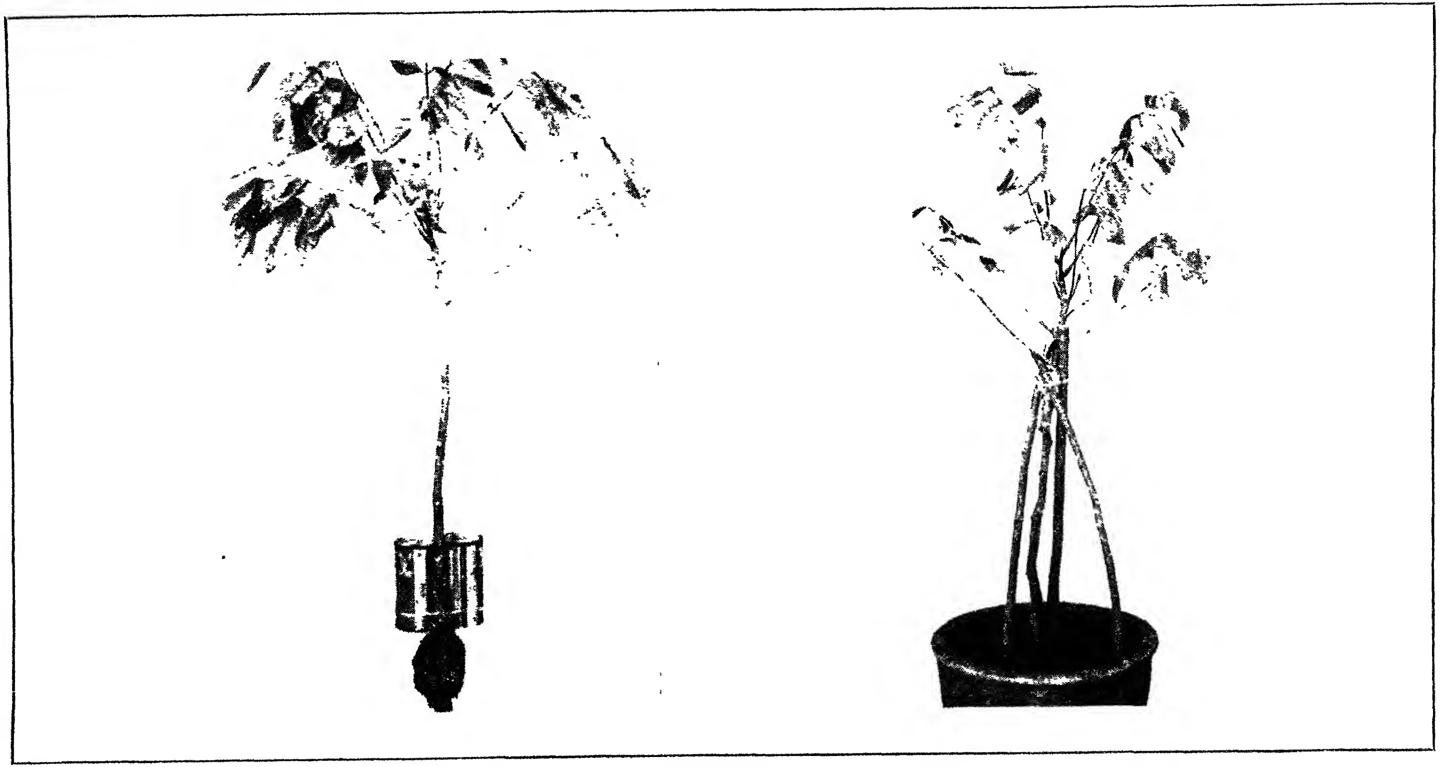

PLATE 2.

A REPORT ON PHILIPPINE BIRDS THAT PREY ON THE ORIENTAL MIGRATORY LOCUST (*LOCUSTA MIGRATORIA MANILENSIS* MEYEN)

By Pablo S. Soriano

Of the Plant Pest and Disease Control Division, Bureau of Plant Industry

SEVEN PLATES

In the control of the Oriental migratory locust (*Locusta migratoria manilensis* Meyen), it has been deemed advisable to secure as much information as possible on birds that prey on the insect so that at least those that are found to be most valuable in this respect might be protected and their multiplication, if possible, encouraged, as a part of the national policy of bird protection and conservation. Reliable information on this subject can, of course, only be secured by carefully examining the contents of the stomachs of birds caught from locust infested areas.

This paper aims to present the data that have been observed so far as a basis for further work, the value of which hardly needs any comment, for it is only from the information obtained in a study of this kind that laws for the protection of certain birds can be logically and properly based. It is needless to state that bird protection and conservation should be based not on sentimental grounds and on casual observations but on definite information on the food habits of such birds, obtained from careful examination of the stomach contents of as many of such birds as could be caught or shot.

MATERIALS

Some of the materials used in this study were taken from the municipalities of Rizal, Laguna and Lemery, Batangas, in 1935 when locusts invaded these places. The rest were taken from Sta. Rita, Samar and from Ormoc, Baybay and Albuera, Leyte, in 1936, when the writer was assigned to these places in connection with locust control work.

The above-mentioned towns in Samar and Leyte were coastal towns. Behind them, for distances ranging from 3 to 7 kilometers, are mountain ranges covered with thick verdant forest. At the foothills, there are trees and shrubs growing abundantly.

In some places below the foothills there are scattered tall trees spared by the homesteaders and it is in these places where the birds of prey used to haunt. Between these places and the coast, are plains where sugar cane, rice, corn, etc., are extensively cultivated and it is in these places where birds, dwellers of open country, are found. It should be stated that the birds collected from these places represent different species living in different strata as regards to type of vegetations and climatic conditions.

METHODS OF STUDY

Field observation of the food habits of birds, although it is useful, is far from being accurate. For example, there are birds found in fruit trees and they have been accused of feeding on the fruits when in fact they do not feed on such fruits. This is also true to the contrary. In order to be more accurate and reliable, stomach examination is necessary. Having this in mind, the writer shot birds representing the different species found in the locust infested areas.

The numerical method has been used in this study, for the writer believes that the amount of injury or benefit that a bird gives depends upon the number of destructive or beneficial animals or crops it destroys.

The insects and other food items in each stomach were counted. If the food had been partially digested, the number of paired mandibles of locust found in the stomach was taken to represent the number of locust taken; the number of paired elytra meant the number of beetles; the number of snouts showed the number of weevils. Any unpaired elytron or mandible was considered as representing one insect.

The percentage was taken by dividing the number of insects or seeds belonging to a certain family or genera or species, as the case may be, by the total number of food items in the stomach and then multiplied by 100. For example, if there are 10 locusts found in the stomach and the total number of food items including the 10 locusts is 100, divide 10 by 100 and then multiply by 100 to get the percentage of locust which is 10 per cent.

RESULTS AND DISCUSSION

In order to give a more comprehensive description of the results obtained, it is deemed proper to indicate other pertinent facts about the birds found to feed on the insect. The vernacular and scientific names were supplied by the Bureau of

Science while the distribution is based on the book, A Manual of Philippine Birds by Richard C. McGregor.

Vernacular names available within the reach of the author are given under each species with the hope that a Filipino reader may have an idea or knowledge of the birds under discussion.

WATERCOCK, *Gallicrex cineria* **(Gmelin). Plate 1, fig. 2.**

This bird is called Tubtub in Ilocos, Bicol and Ticao; Cannutok, Manila; Tapayan, Cebu; Tuyud, Bohol; Tugtug, Masbate.

This species is found throughout the Philippine Islands.

It is abundant in rice fields and marshes in some localities. It walks and it has the gait of our domestic chicken. When an enemy approaches, it walks away, always keeping an eye on the enemy. It nests in the rice field and, when it does, it builds its nest out of the rice plants, thus destroying them.

Two birds were shot in Ormoc, Leyte, and their stomach contents examined. There were found 3 locusts, which made up 0.4 per cent of the food contents; 1 katydid, 1 cricket and 1 weevil, 0.4 per cent; 5 unidentified insects and snails, 0.7 per cent; 688 weed seeds which made up 98.4 per cent of the entire stomach contents.

PHILIPPINE ASHY CRAKE, *Poliolimnas cinereus collingwoodi* **Mathews.**

This bird is called Toclin in Ilocos; Tighik, Cebu; Ticling, Tica, or Matang bayani, Tagalog.

It is common among the grasses and reeds about lakes, marshes and creeks. It walks and has the gait of a domestic chicken. It builds its nest in the tall grasses and bushes.

The only bird shot in Ormoc, Leyte, showed in its stomach 7 locust hoppers, or 87.5 per cent of the contents, and 1 darkling beetle, 12.5 per cent.

INDIAN CATTLE EGRET, *Ardeola ibis coromanda* **(Boddaert). Plate 1, fig. 1.**

This species is called Cannaway in Ilocos and Pangasinan; Tagac, Tagalog and Pampango; Talabon, Talabong, Tabon, or Tabong, Eastern Visaya; Talaud, Bicol; Taguak, Calayan.

It is found throughout the Philippine Islands.

This bird is sometimes seen either singly or in pairs, but mostly in flocks of over hundred individuals. They are usually found in wet fields, marshes and along lakes, ponds and creeks. Birds are at times seen on the back of carabaos. When the bird flies, the neck is withdrawn and the long legs are extended backward, appearing to be like a tail. Sometimes a flock or

flocks in military formation are seen hovering over rice fields. It breeds in marshes.

Two stomachs taken in Lemery, Batangas, were examined and found to contain 44 locusts, 50 per cent of the food contents; 18 crickets, 20 per cent; 3 katydids, 3 per cent; 5 grasshoppers, 6 per cent; 12 spiders, 14 per cent; 6 unidentified insects, 7 per cent.

It has been observed that this bird feeds voraciously on locust. Due to its big size and the great number of individuals in a flock, doubtless a flock can consume lots of locusts in a day. Some local officials like those of Palo, Leyte, Cotabato, Cotabato and others, recognize this and in return to the great help this bird renders in the suppression of locust infestation and other insect pests, they passed ordinances prohibiting the catching and killing of this species.

It has also been observed that this species prey at times on fishes, crustaceans and amphibians, but not to a considerable extent.

TIC-WEE BUZZARD, Butastur indicus (Gmelin). Plate 2, fig. 1.

This species is called Limbas in Tagalog; Tic-wee, Ilocos and Eastern Visaya; Cuyab, Calayan.

It is found throughout the Philippine Islands.

It is common. It is either seen singly, in pairs or in flocks. It is usually found in places where there are few tall trees in an open field. Being a bird of prey, the tall trees serve as good vantage points for its lookout. It nests in tall trees.

The three stomachs collected in Ormoc, Leyte, contained 59 locust flyers, 98 per cent of the food contents; 1 unidentified insect, 2 per cent. These were the birds seen catching locust flyers in a swarm.

This bird has been observed taking flyers on the wing either with its bill or its claws, but mostly with the latter. When it takes a locust flyer with its bill, it usually alights in a nearby tree where it devours the victim; when it takes one with its claws, it usually devours it in the air.

Flocks of this bird sometimes serve as a good guide for locust scouters in the location and direction of flights of locust swarms. When a flock is seen hovering at a distance (a distance that the swarm of locust flyers is not visible to the naked eye) and the birds dart now and then, it is a sign that a swarm of locust flyers is being followed by the flock.

This species has been seen taking chicks and chasing small birds.

MALAYAN BRAHMING KITE, Haliastur indus intermedius Gurney. Plate 2, fig. 2.

This bird is called Kali in Ilocos; Lawin, Tagalog; Banog, Eastern Visaya; Baga, Pangasinan.

It is found throughout the Philippine Islands.

It is seen either singly, in pairs or in flocks. Flocks are usually found together with those of the Tic-wee buzzard in ports and along the coasts where there are many fishermen, for they feed on dead fishes purposely thrown away during sorting and incidentally during unloading, and refuses thrown overboard from ships. It is seldom found far inland.

One bird was shot in Ormoc, Leyte, and its half-filled stomach contained 7 locust flyers, the only food contents. This bird was busy taking flyers when it was shot. If allowed to continue, it would have taken more perhaps. Like the Tic-wee buzzard, a flock serves as a good guide for locust scouters to locate the swarm of locust flyers and determine its direction.

This bird was seen taking snakes and chasing small birds.

BROAD-BILLED ROLLER, Eurystamus orientalis orientalis (Linneaus). Plate 4, fig. 2.

This species is called Loro inchik in Tagalog; Langas, Cagayancillo; Tagalas, Calayan; Salaksakan, Ticao; Salak, Leyte; Balisaksak, Negros Oriental.

It is found throughout the Philippine Islands.

This bird is not so common. It is usually seen singly perching quietly on dead branches of trees where it could have a good lookout. It takes its prey on the wing and usually returns to the same perching place where it devours or swallows, depending upon the size of the victim.

There were two stomachs taken, one in Sta. Rita, Samar and the other in Albuera, Leyte, and they contained 3 locust flyers, 27 per cent of the food contents; 2 katydids, 18 per cent; 2 hemiptera, 19 per cent; 1 June beetle, 9 per cent; 3 unidentified insects, 27 per cent.

WHITE-COLLARED KINGFISHER, Halcyon chloris collaris (Boddaert). Plate 5, fig. 6.

This bird is called Salaksak in Ilocos; Kasaykasay, Tagalog; Ticarol, Eastern Visaya; Batala, Pampango; Salaksakan, Iloilo; Barita, Bicol; Bakakà, Samar and Leyte; Takarit, Ticao; Takray, Panay.

It is found throughout the Philippine Islands.

It is very common, especially along wooded streams, mangrove swamps and seashores. At times it is seen darting into the water to get its prey. It is seen either singly or in pairs.

It is noisy during mating season which takes place in the months of May and June.

One stomach taken in Sta. Rita, Samar, contained 8 locust flyers, the only food contents.

It has been observed that this bird takes fishes, reptiles, crustaceans and amphibians.

WHITE-THROATED KINGFISHER, *Halcyon smyrnensis gularis* (Kuhl). Plate 5, fig. 4.

This species is called Tigmamanok in Tagalog; Bakaka, Samar and Leyte; Salaksakan, Negros Oriental; Salaksak, Ilocos.

It is found throughout the Philippine Islands.

It is usually found among the trees and shrubs along fresh-water streams. It is either seen singly or in pairs. Like the white-collared kingfisher, it is noisy during mating season which takes place in the months of May and June. It breeds mostly along river banks.

The stomach taken in Baybay, Leyte, was almost empty. It contained 1 locust flyer, 50 per cent of the food contents; 1 unidentified insect, 50 per cent.

Like the white-collared kingfisher it has been observed taking fishes, crustaceans and amphibians.

SAMAR TARIKTIK, *Penelopides panini samarensis* (Steere). Plate 3, fig. 1.

This bird is called Tariktik in Ilocos and Tagalog; Taosi or Talusi, Bohol, Samar and Leyte.

It is found only in the Provinces of Samar, Leyte, and Bohol, Philippine Islands.

It is seen singly but frequently either in pairs or in groups. It is a tree dweller. It is noisy and of heavy flight.

There were three stomachs collected in Ormoc, Leyte, and they contained 3 locust flyers, 25 per cent; 1 unidentified insect, 8 per cent; 4 June beetles, 33 per cent; 4 seeds of wild fruit trees, 34 per cent.

GREEN-HEADED BEEBIRD, *Merops superciliosus philippinus* Linneaus. Plate 6, fig. 8.

This bird is called Pirpirio in Ilocos; Parikparik or Pirik, Tagalog; Purokpurok, Eastern Visaya; Patiriktirik, Pampango, Pilio, Negros Oriental.

It is found throughout the Philippine Islands.

This bird is seen in pairs but mostly in flocks. It is usually found in open places. It perches where it can have a good outlook of the surroundings. Telegraph posts and lines are good vantage points where it ordinarily scans the ground for a prey.

It seems that trees and shrubs could not adequately supply for a lookout. From its perching place, it flies then soars and then glides to the same or other perching place and it does this several times with its characteristic note "piriw, piriw, piriw." It nests in colonies in sandy steep banks.

The four stomachs collected, one in Rizal, Laguna and the others in Ormoc, Leyte, contained 3 locust flyers, 19 per cent of the food contents; 1 katydid, 6 per cent; 1 carrion beetle, 6 per cent; 1 long-horned beetle, 6 per cent; 6 hymenoptera, 37.5 per cent; 4 unidentified insects, 25 per cent.

This bird takes locust flyers on the wing with its bill. After it has taken one it goes to perch, kills the victim by bumping it on the perch and then swallows it.

RED-WINGED COUCAL, Centropus viridis (Scopoli).

This bird is called Cacuk in Ilocos; Sabucot or Saguksuk, Tagalog; Cucuk, Eastern Visaya; Siabukut, Pampango; Saguksuk, Western Visaya and Bicol.

It is found throughout the Pilippine Islands.

It is a solitary bird and commonly found in bushes and tall grasses in the open country. It is heavy on its flight and it does not fly high and far. When it is scared and pressed, it flies and then dives into the grasses where it can make a good escape from its enemy. It nests mostly in tall grasses.

There were two stomachs taken, one in Sta. Rita, Samar and the other in Ormoc, Leyte, and they contained 6 locust flyers, 86 per cent of the food contents; 1 grasshopper, 14 per cent.

JAVAN COUCAL, Centropus bengalensis javanensis (Dumont). Plate 4, fig. 1.

This bird is called Cacuk in Ilocos; Sabucot or Saguksuk, Tagalog; Cucuk, Eastern Visaya.

It is found throughout the Philipine Islands.

Its habit is similar to that of the red-winged coucal.

The only stomach taken in Ormoc, Leyte, contained two locust flyers, the only food contents.

COMMON SWALLOW, Hirundo rustica guttoralis Scopoli. Plate 6, fig. 2.

This bird is called Sal-lapiñgao in Ilocos; Layanglayang or Lañgaylañgayan, Tagalog, Balinsasayao or Sayao, Eastern Visaya; Sibad, Pampango.

This species is found throughout the Philippine Islands.

It is seen in open places in flocks which are sometimes composed of over hundred individuals. It usually alights on places

where it can have a good outlook of the surroundings for it takes its prey mostly on the wing. It is sometimes seen in towns flying low and fast zigzagly through thoroughfares even if there are plenty of people. During cloudy days at the approach of rain, several are seen flying unsteadily at random above grasses in open field and above the houses in towns. It nests in caves and abandoned houses. The nest is made of mud attached to rocks and beams.

There were three stomachs taken in Ormoc, Leyte and they contained 39 locust hoppers of the second and third stages, 67 per cent of the food contents; 1 June beetle, 2 per cent; 6 weevils, 10 per cent; 1 homoptera, 2 per cent; 2 hemiptera, 3 per cent; 7 hymenoptera, 12 per cent; 2 unidentified insects, 3 per cent.

By nature this bird takes its prey on the wing, but it also takes its victim on the ground when it finds it convenient. The writer has observed this species taking hoppers by flying low over them and snapped one hopper as it jumped when it was scared by its approach. It was also observed alighting on the ground to pick the hoppers. Being a small bird, it could take chiefly hoppers of the first, second, and third stages.

KOCK'S ARTAMIDES, *Coracina striata kochi* (Kutter). Plate 5, fig. 2.

This species is called Kiakia in Leyte; Baboybaboyan, Novaliches, Rizal.

It is found throughout the Philippine Islands.

It is usually found in trees in the foothills.

The only stomach taken in Ormoc, Leyte, was almost empty; it contained only 1 locust flyer, 50 per cent of the food contents; 1 June beetle, 50 per cent.

GUAVA BULBUL, *Pycnonotus goiavier goiavier* (Scopoli). Plate 6, fig. 1.

This species is called Luklak, Pulañgo, or Kalaga in Tagalog and Pampango; Piroca, Ilocos; Curao or Culcul, Cebu; Parago or Palogo, Samar and Leyte; Agol-ol, Misamis.

This bird is found throughout the Philippine Islands.

It is common in fruit trees, bushes and shrubs in the plains, but not in deep forests. It is often seen in pairs, but also in flocks in a tree bearing plenty of fruits which they relish. It nests mostly in bushes and shrubs.

The only stomach taken in Rizal, Laguna, contained 11 locust hoppers, the only food contents.

PIED CHAT, *Saxicola caprata caprata* Linneaus. Plate 6, fig. 3.

This bird is called Sipao, Taing baboy, or Tererekoy in Tagalog; Maria capra, Pampango.

It is found throughout the Philippine Islands.

It is usually found either singly or in pairs in shrubs and grasses where it can have a good outlook in the open country. It is restless, always spreading and jerking its tail when it is perching.

The stomach taken in Rizal, Laguna, contained 12 locust hoppers, 50 per cent of the food contents; 1 June beetle, 4 per cent; 2 hemiptera, 8 per cent; 3 hymenoptera, 13 per cent; 6 unidentified insects, 25 per cent. Being a small bird, it could take only hoppers of the first, second and third stages.

GOLDEN-HEADED CISTICOLA *Cisticola exilis rustica* Wallace. Plate 6, fig. 4.

This bird is called Pipit cogon in Tagalog; Perit or Pirot, Eastern Visaya.

It is found throughout the Philippine Islands.

It is found among the grasses in an open country. It is sometimes seen perching on tall grasses and shrubs. When it is disturbed, it flies in a jerky way to a short distance and then dives among the grasses where it could make a good escape from the intruder.

The stomach taken in Ormoc, Leyte, contained 1 locust hopper, 25 per cent of the food contents; 1 katydid, 25 per cent; 1 grasshopper, 25 per cent; 1 unidentified insect, 25 per cent. Being a small bird, it could take only hoppers of the first, second and third stages.

STRIATED MARSH WARBLER *Megalurus palustris forbesi* Bangs. Plate 6, fig. 6.

This species is called Tiktikrobong in Ilocos; Sunod kalabao, Tortoriok, or Tintiriok, Tagalog; Trotoriok, Eastern Visaya; Bacabaca, Pampango.

It is found throughout the Philippine Islands.

It is mostly seen either singly or in pairs in tall grasses in the open country. It is very fond of singing and its song has a ventriloquial quality. It is a slow and heavy flyer like the coucal. It walks fast on the ground and hides in patches of grasses or thickets when it sees a person.

The two stomachs taken, one in Ormoc, Leyte and the other in Baybay of the same province, contained 6 locusts, 86 per cent of the food contents; 1 katydid, 14 per cent.

WHITE-BELLIED SWALLOW SHRIKE, Artamus leucorhyncus leucorhyncus (Linneaus). Plate 6, fig. 5.

This species is called Gitgit or Gikgik in Ilocos; Pagatpat, Tagalog; Gitgit, Eastern Visaya; Alo-it-it, Panay; It-it, Misamis.

It is found throughout the Philippine Islands.

It is seen either in pairs or in flocks, and usually perches on coconut fronds, telegraph lines, top of barns or any place where it can have a good outlook of the surroundings, for it gets its prey on the wing. It is aggressive; it drives away any bird that comes nearby; it always chases a crow or a hawk that passes by.

There were two stomachs taken, one in Rizal, Laguna and the other in Sta. Rita, Samar, and they contained 5 locusts, 71 per cent of the food contents; 2 unidentified insects, 29 per cent.

LARGE-NOSED SHRIKE, Lanius schach nasutus (Scopoli). Plate 5, fig. 7.

This bird is called Verdugo in Ilocos; Tarat San Diego, Kamugot, or Cabesote, Tagalog; Verdugo or Ma-mu-muñgat, Eastern Visaya; Tarat bulan, Pampango.

This species is found throughout the Philippine Islands.

It is mostly seen singly in low trees, shrubs, fences and telegraph lines in open country. It usually perches on a vantage point where it can see well the surroundings. It is an aggressive bird, always ready to drive away a bird intruder. It is a slow and heavy flyer, like the striated marsh warbler.

The two stomachs collected, one in Rizal, Laguna and the other in Ormoc, Leyte, contained 20 locust hoppers, 95 per cent of the food contents; 1 unidentified insect, 5 per cent.

This bird has been observed taking small rodents and chasing small birds.

GRAY WAGTAIL, Motacilla melanope Pallas.

This species is called Sarsarakinod or Gigiot in Ilocos and Pangasinan; Baticulo or Pipit kakaniud, Tagalog; Titidiot, Bangkiyud, or Kiyudkiyud, Eastern Visaya.

It is found throughout the Philippine Islands.

It is usually found either singly or in pairs, or in flocks in the presence of abundant food supply in open fields. When one is walking in the field, he is caught unaware by the sudden flush of this bird. It has a wavering flight as though constantly proposing to alight. It is restless, always moving up and down the posterior part of the body even when it is walking.

There were two stomachs collected, one in Baybay, Leyte and the other in Ormoc of the same province. They contained 6 lo-

cust hoppers, 60 per cent of the food contents; 4 unidentified insects, 40 per cent.

Sometimes this bird is seen in big flocks, numbering over a hundred individuals. A big flock can surely do a great help in the destruction of locust hoppers. The writer had observed a flock of over 70 individuals that controlled a locust-hopper infestation covering one-fourth of a hectare within two weeks. It takes its prey as it runs and hops.

PHILIPPINE ORIOLE, Oriolus chinensis chinensis Linn. Plate 5, fig. 1.

This bird is called Kiao in Ilocos; Kuliawan, Tagalog; Tulihao or Antulihao, Eastern Visaya; Duyao or Kikiyao, Bicol; Tulihao, Western Visaya.

It is found throughout the Philippine Islands.

It is seen in pairs in trees and shrubs. It is a strong flyer, making undulation in its flight as in the case of some passerin birds. Its characteristic note is "kiao or kuliawan or tulihao" from which the natives derive its name as in other birds, for the natives usually name the bird after its characteristic note.

The two stomachs collected, one in Albuera, Leyte and the other in Sta. Rita, Samar, contained 1 locust, 4 per cent of the food contents; 3 unidentified insects, 11 per cent; 22 seeds of wild fruit trees, 85 per cent.

NORTHERN DRONGO, Dicrurus hottentottus striatus Tweeddale. Plate 5, fig. 3.

This species is called Wakwak or Agad-agad in Eastern Visaya; Putol susô, Mindoro.

It is found throughout the Philippine Islands.

It is not common. It is found in pairs under bushes near the forest.

There were two stomachs collected in Albuera, Leyte, and they contained 5 locust hoppers, 33 per cent of the food contents; 2 katydids, 13 per cent; 2 weevils, 13 per cent; 2 hymenoptera, 13 per cent; 1 leaf beetle, 7 per cent; 3 unidentified insects, 20 per cent.

BLACK-BACKED COLETO, Sarcops melanonotus Grant. Plate 4, fig. 3.

This bird is called Coleto or Coling in Ilocos and Tagalog; Saling, Cebu; Iling, Western Visaya; Sungko langit or Coling, Mindoro; Coling, Northern Mindanao.

It is found throughout the Philippine Islands.

The black-backed coleto is found either in pairs or in flocks. It has a characteristic note "coling" which is high pitch and metallic. It is a heavy flyer. When it flies the flapping of the wings is very audible even at a distance.

cost hoppers, 60 per cent of the food contents; 4 unidentified

The two stomachs taken in Sta. Rita, Samar, contained 1 locust flyer, 6 per cent of the food contents; 17 seeds of wild fruit trees, 94 per cent.

PHILIPPINE GLOSSY STARLING Aplonis panayensis panayensis (Scopoli). Plate 6, fig. 7.

This species is called Pius in Ilocos; Coraching, Tagalog; Galanciang, Ganciang, or Mandeleciang, Eastern Visaya.

It is found throughout the Philippine Islands.

It is seen either in pairs or in flocks. It is this species that nests in the bamboo tubes placed in the acacia trees in front of the city hall of Cebu, Cebu, and the municipal hall of Ormoc, Leyte. It is hard to distinguish between the northern drongo and this bird at a distance, but anyone who is acquainted with their habitats can easily tell which is which because the northern drongo lives in a lower strata and away from towns while the other lives in a higher strata and often seen in towns.

There were 3 stomachs taken in Ormoc, Leyte and they contained 1 locust flyer, 33 per cent of the food contents; 2 seeds of wild fruit tree, 67 per cent.

This species was seen catching flyers on the wing. It catches the flyers with its bill and then goes to perch. It kills the victim by bumping it on the perch after which it swallows.

CHINESE STARLING, Aetheopsar cristatellus Linneaus. Plate 5, fig. 5.

This bird is called Martinez in Ilocos and Tagalog.

It is found only in the island of Luzon, Philippine Islands.

It is said that this bird was imported from China by the Spanish Governor, Juan Martinez, to combat the locust plague. It is seen either in pairs or in flocks. A big flock is sometimes seen in places where garbage are dumped for they feed on some of the refuses, and pig pens to have a share of the pig's feed.

There were three stomachs collected in Lemery, Batangas, and they contained 16 locust flyers, 51 per cent of the food contents; 5 grasshoppers, 16 per cent; 2 katydids, 6 per cent; 6 unidentified insects, 19 per cent; 2 seeds of wild fruit trees, 6 per cent.

PHILIPPINE CROW, Corvus coronoides philippinus Bonaparte. Plate 3, fig. 2.

This bird is called Wak in the native dialects.

It is found in all the provinces, except Palawan, in the Philippine Islands.

It is usually seen either in pairs or in flocks. It is a heavy flyer, but it can fly far. Its characteristic note is "wak-wak-wak."

There were five stomachs taken, one in Lemery, Batangas, two in Sta. Rita, Samar, two in Ormoc, Leyte, and they contained 18 locusts, 15 per cent of the food contents; 1 katydid, 0.8 per cent; 7 dried fruit beetles, 6 per cent; 2 unidentified insects, 1.2 per cent; 20 seeds of peanut, 16 per cent; 52 kernels of young corn, 43 per cent; 22 seeds of wild fruit trees, 18 per cent.

It is said that crow are good guides for locust scouters in locating locust infestations, especially hopper infestations. In some cases this is true, but in other cases it is not. The writer shot a crow in a peanut field infested with young flyers and hoppers. It was found that the stomach did not contain any trace of locust, but all peanut seeds. In another case the writer shot a crow in a corn plantation infested with hoppers of the different stages. The corn plants were having young ears. It was found that the stomach did not contain locust, but young kernels of corn and dried fruit beetles. These show that the crow forsakes the locust in the presence of peanuts and young ears of corn.

This species has been observed destroying eggs and preying on chicks and small birds.

SUMMARY AND CONCLUSIONS

From the results of the observation so far, as presented in this paper, the following birds are decidedly good locust eaters:

1. Malayan Brahming Kite, *Haliastvr indus intermedius* Gurney.
2. White-throated Kingfisher, *Halcyon smyrueulis gularis* (Kuhl).
3. Javan Coucal, *Centropus bengalensis javanensis* (Dumont).
4. Guava Bulbul, *Pycnonotus goiavier goiavier* (Scopoli).
5. Tic-wee Buzzard, *Butastur indicus* (Gmelin).
6. Large-nosed Shrike, *Lanius schach nasutus* (Scopoli).
7. Philippine Ashy Crake, *Poliolimnas cinereous collingwoodi* Mathews.
8. Red-winged Coucal, *Centropus viridis* (Scopoli).
9. Striated Marsh Warbler, *Megalurus palustris forbesi* Bangs.
10. White-bellied Swallow Shrike, *Artamus leucorhyncus leucorhyncus* (Linneaus).
11. Common Swallow, *Hirundo rustica gutturalis* Scopoli.
12. Gray Wagtail, *Motacilla melanope* Pallas.
13. Chinese Starling, *Aetheopsar cristatellus* Linneaus.
14. Indian Cattle Egret, *Ardeola ibis coromanda* Linneaus.
15. Pied Chat, *Saxicola caprata caprata* (Linneaus).
16. White-collared Kingfisher, *Halcyon choris collaris* (Scopoli).
17. Koch's Artamides, *Coracina striata kochi* (Kutter).

The following birds are partial locust eaters:

1. Philippine Glossy Starling, *Aplonis panayensis panayensis* (Scopoli).
2. Northern Drongo, *Dicrurus hottentottus striatus* Tweeddale.
3. Broad-billed Roller, *Eurystamus orientalis orientalis* (Linneaus).
4. Golden-headed Cisticola, *Cisticola exilis rustica* Wallace.
5. Samar Tariktik, *Penelopides panini samarensis* (Steere).
6. Green-headed Beebird, *Merops superciliosus philippinus* Linneaus.
7. Black-backed Coleto, *Sarcops melanonotus* Grant.
8. Philippine Oriole, *Oriolus chinensis chinensis* Linneaus.
9. Watercock, *Gallicrex cineria* (Gmelin).
10. Philippine Crow, *Corvus coronoides philippinus* Bonaparte.

The following birds are locust eaters but at times they do injury to certain crops and fruits. However, the damage done is often insignificant as to be ignored. Moreover, most of the fruits eaten are mostly those of wild trees.

1. Philippine Crow, *Corvus coronoides philippinus* Bonaparte.
2. Philippine Glossy Starling, *Aplonis panayensis panayensis* (Scopoli).
3. Black-backed Coleto, *Sarcops melanonotus* Grant.
4. Chinese Starling, *Aetheopsar cristatellus* Linneaus.
5. Philippine Oriole, *Oriolus chinensis chinensis* Linneaus.
6. Guava Bulbul, *Pycnonotus goiavier goiavier* (Scopoli).

The following birds are good locust eaters, but at times attack poultry and small beneficial birds, as has been observed in the field:

1. Tic-wee Buzzard, *Butastur indicus* (Gmelin).
2. Malayan Brahming Kite, *Haliastur indus intermedius* Gurney.
3. Philippine Crow, *Corvus coronoides philippinus* Bonaparte.
4. Large-nosed Shrike, *Lanius schach nasutus* (Scopoli).

The following birds as their names suggest except the Indian cattle egret, take a great deal of locust but feed on small fishes:

1. White-collared Kingfishers, *Halcyon chloris collaris* (Scopoli).
2. White-throated Kingfisher, *Halcyon smyrneulis gullaris* (Kuhl).
3. Indian Cattle Egret, *Ardeola ibis coromanda* (Boddaert).

SUGGESTIONS

No matter how few the number of locusts a bird eats, it is without doubt valuable in the suppression of the pest, especially if the species is abundant. If a locust eating bird is not actually doing damage to crops in the locust infested regions, it should be left alone to continue its beneficial work; if it does damage to crops more than it does to the pest, as the Philippine crow

at times it should be controlled or driven away. Those that are decidedly locust eaters which do not damage crops, poultry, etc., as the Indian cattle egret, striated marsh warbler, gray wagtail, white-bellied swallow shrike, large-nosed shrike, common swallow, etc., should be protected by municipal ordinances in accordance with existing laws, such as those passed by the municipal council of Palo, Leyte, Cotabato, etc., in connection with the Indian cattle egret prohibiting their destruction in any manner. Their multiplication, if possible should be encouraged by providing them with adequate breeding places. Existing laws dealing with bird protection and conservation should be rigidly and adequately enforced.

ACKNOWLEDGMENT

This study was suggested and encouraged by Dr. Gonzalo Merino and Mr. Faustino Q. Otanes, Chief and Assistant Chief of the Plant Pest and Disease Control Division of the Bureau of Plant Industry, respectively, who were responsible for the writer's assignment to the locust control work to give him an opportunity to observe and collect materials for this study and who gladly and immediately approved the acquisition of materials needed for the collection.

Thanks are due to Dr. Canuto G. Manuel, Ornithologist of the Bureau of Science, for his timely criticisms and suggestions.

ILLUSTRATIONS

PLATE 1.

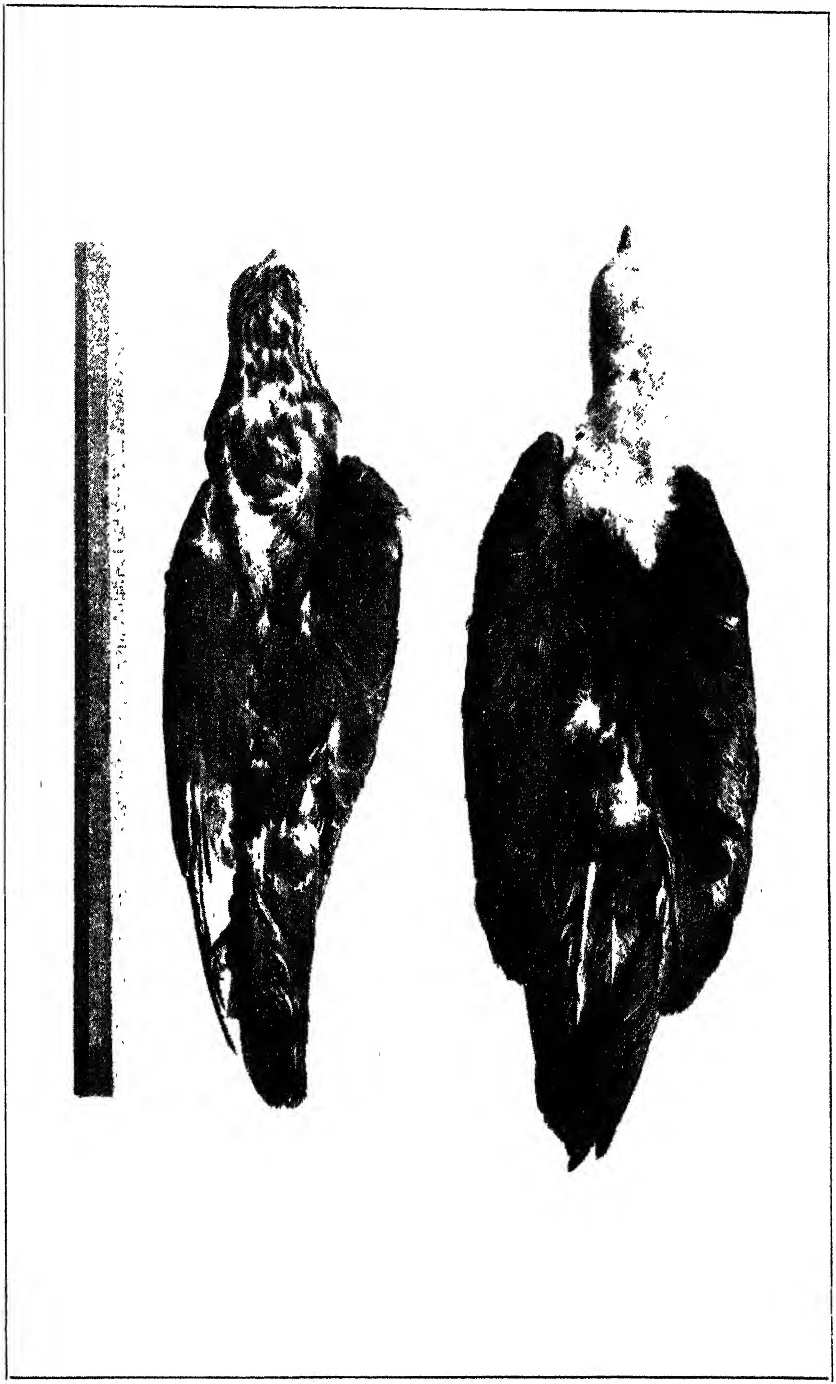

PLATE 2.

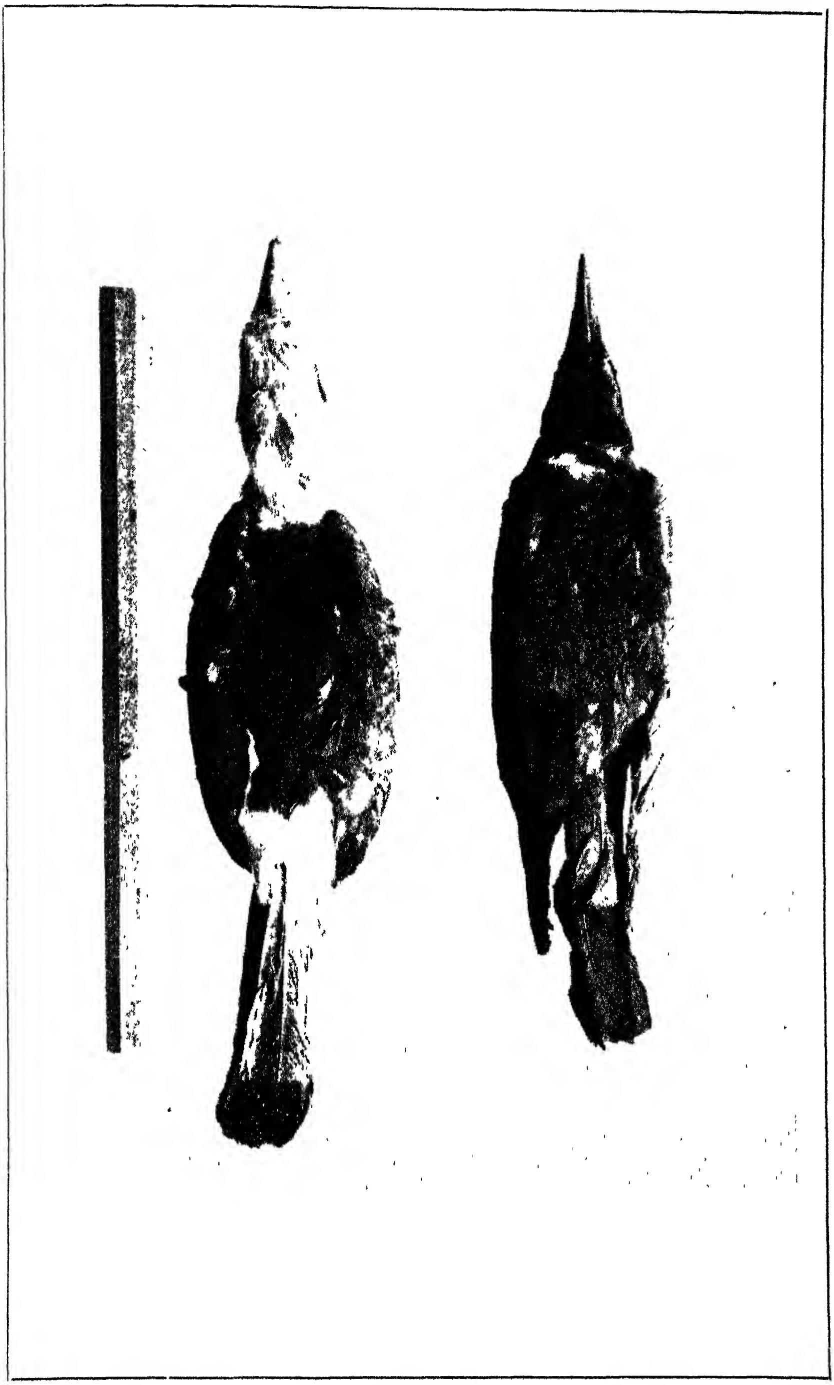

PLATE 3.

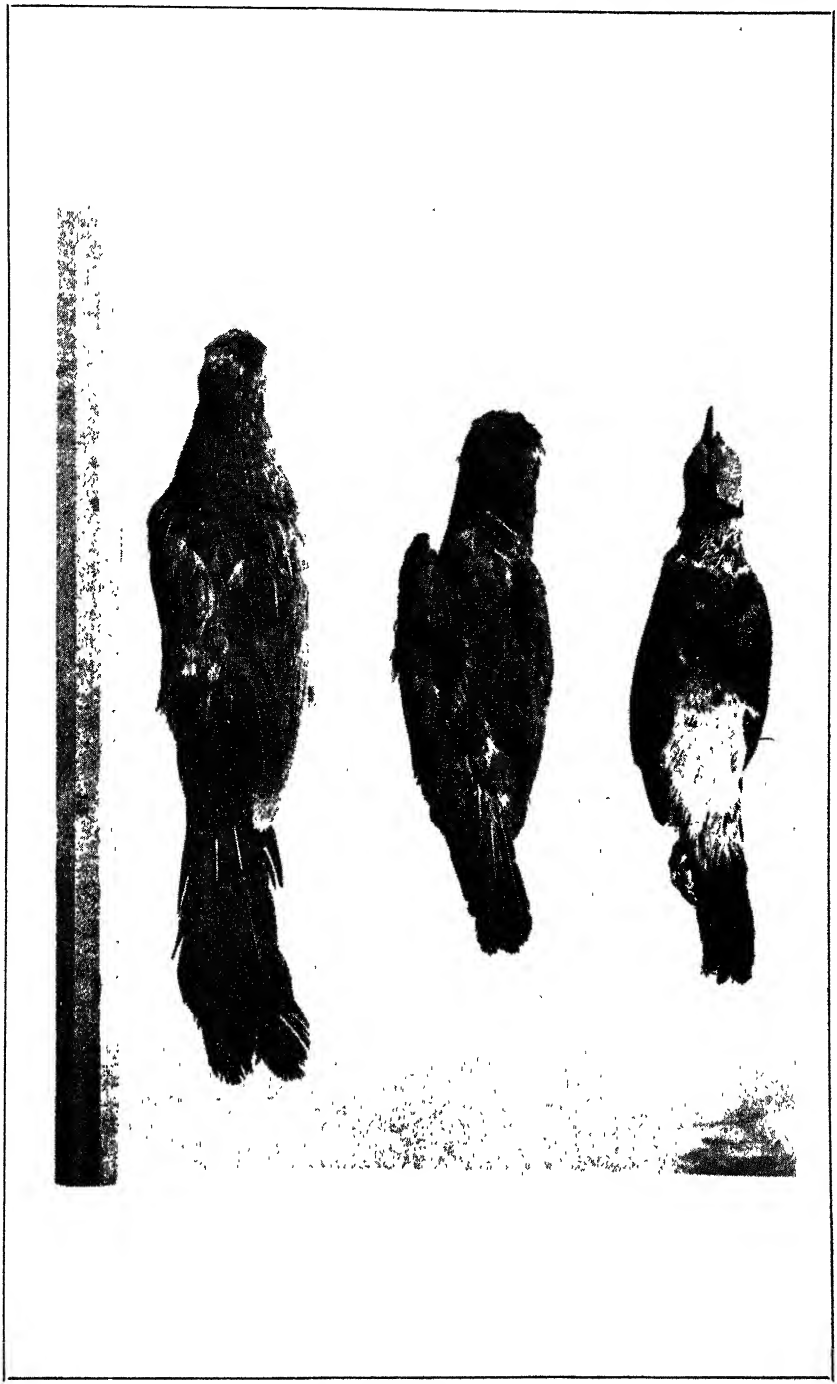

PLATE 4.

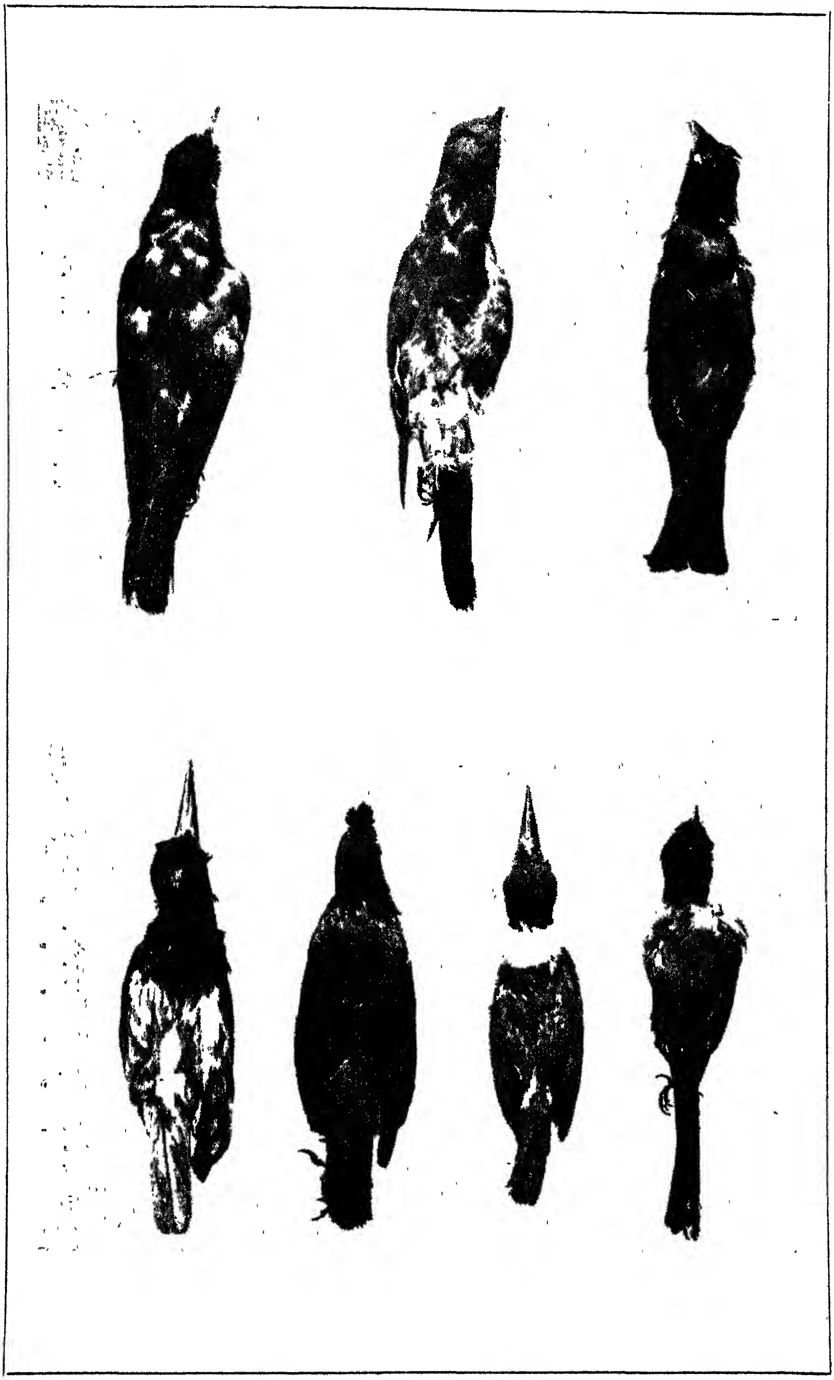

PLATE 5.

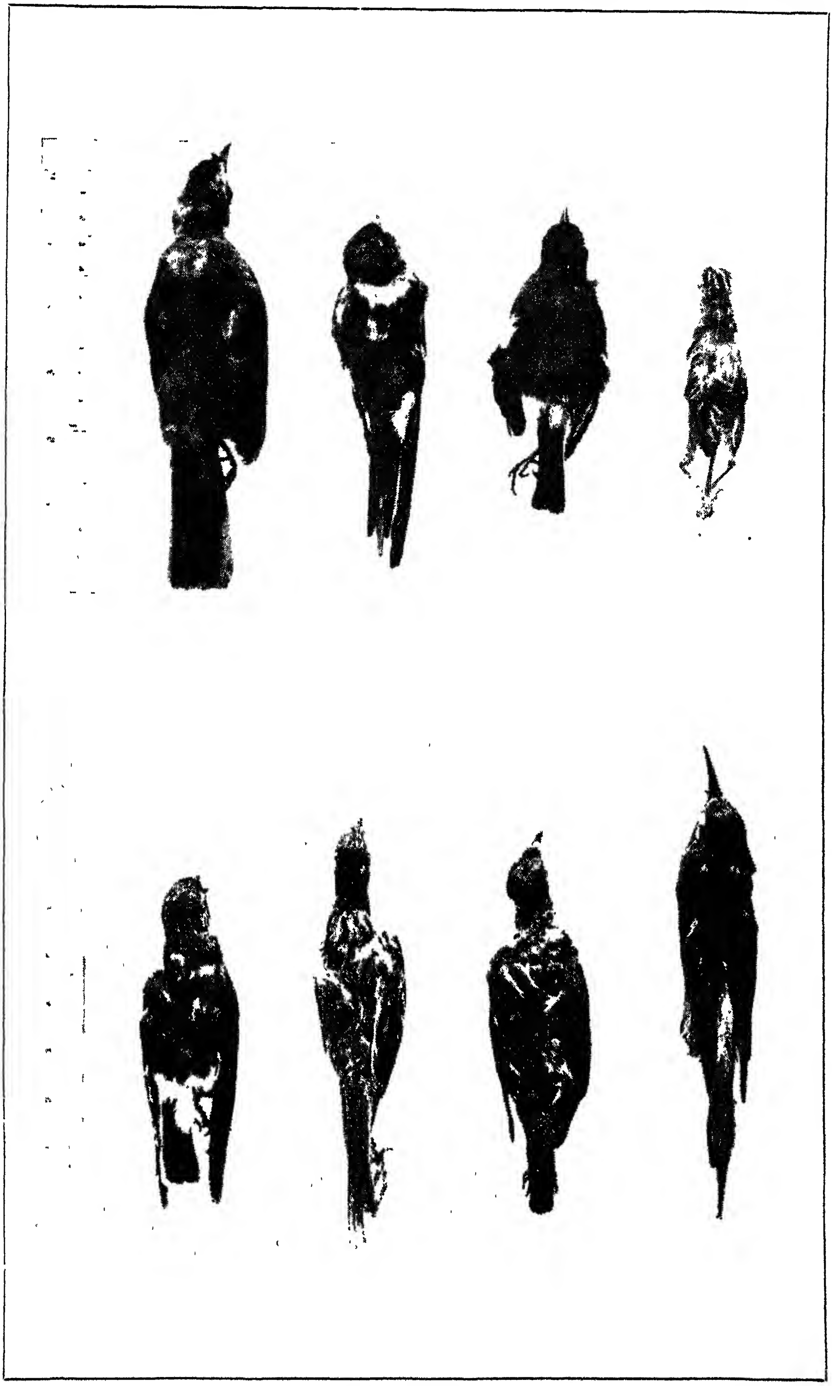

PLATE 6.

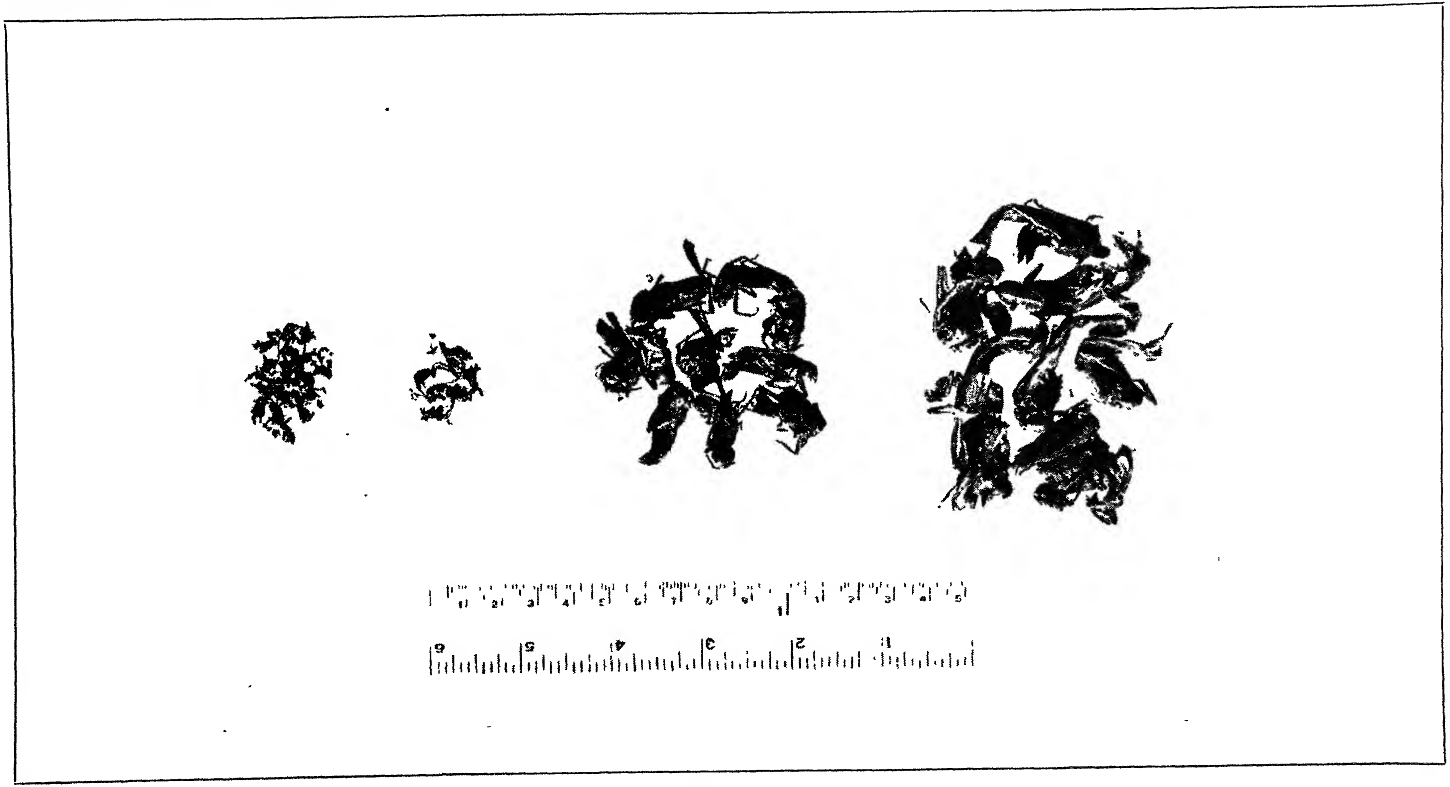

PLATE 7.

INFLUENCE OF THE NUMBER OF LEAVES ON THE DEVELOPMENT AND QUALITY OF CARABAO MANGO FRUITS

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TWO TEXT FIGURES

One of the most salable and well liked fruits in the Philippines is mango, *Mangifera indica* L. The Carabao variety because of its superior quality is much more preferred to any other mango varieties. Mango fruits in a limited quantity are being exported annually especially to Hongkong and China. In 1936, this export amounted to 1,289,480 kilos of fresh fruits valued at ₱125,762 as against 2,610,747 kilos, worth ₱273,871 in 1935. Heretofore, in spite of the popularity of the mango fruits, very little work if any, has been attempted to find some means of improving and standardizing its size and quality so as to suit the taste of the discriminating public and to command a better price in the market.

Although the size and quality of the fruits of a variety or a strain of a certain fruit tree may be influenced by various factors, such as light, heat, moisture, age of the tree, the fertility of the soil, etc., yet the most fundamental requirement of the production of fruits of good quality is the careful selection of the planting material, because the quality of the fruit depends to a great extent on the hereditary characters of the bud and the root stock, regardless of the combined effects of all the aforementioned factors.

It seems also a common belief that poorly developed fruits are largely due to the insufficient number of leaves supporting the fruits, which may either be due to old age, to poor root system, or to the poor fertility of the soil. In the case of apple, pear, and citrus, it was found that the size and quality of the fruits depend on the number of leaves supporting them. The present study aims to find the influence of the number of leaves on growth, size, weight and quality of carabao mango fruits.

REVIEW OF LITERATURE

Kraybill *et al.*(4) and Magnes *et al*(5) studied the influence of the leaf-area on the development of the fruits of apple and pear. The work of Shamel and Pomeroy(6), (7), (8), (9), and (10) dealt mostly with different Citrus fruits, such as Washington Navel orange, Marsh grapefruit, Valencia orange, and Eureka lemon. These authors aimed to determine the number of leaves necessary to bring a single fruit to a commercial size and quality.

According to Kraybill *et al.*(4), 30 leaves were necessary to produce a good apple fruit. Any further increase to this number of leaves did not appreciably improve the size of the fruit. They also state that fruits of apple and pear grown with greater leaf-area were not only larger but higher in sugar content, higher in acidity, and on the whole, had better flavor than the fruits grown with reduced amount of foliage. The same authors also found that apple branches allowed 10 to 20 leaves per fruit neither thickened nor formed flower buds the year following, except Jonathan and Rome Beauty and some in Delicious and Winesap varieties, whereas with 40 to 50 leaves, developed blossoms freely in all the varieties.

Magnes *et al.*(5) state that the greater the leaf-area, the less proportionate, in size, is the fruit. For instance, these authors found that with 10 leaves per fruit of apple there was an increase in volume of the fruits from slightly less than 40 to 180 cubic centimeters, or a gain of 140 cubic centimeters per box of fruits. With 20 leaves per fruit, the gain was only 30 to 250 cubic centimeters, or a gain only of 220 cubic centimeters per box. Thus, it might be seen that although the number of leaves was doubled, the gain per fruit was not proportionately increased. The response of pears to the same treatment was similar to that of the apple.

Shamel *et al.*(6), (7), (8), (9), and (10) did not only observe the relation of growth and the ultimate size of fruits to the number of leaves of the Citrus varieties they worked with but also the influence of light duration on the size of the fruits. For instance, they found the fruits on the northern side larger than those on the southern side. These authors found that in the case of Washington Navel orange, 50 to 60 leaves per fruit was as good as those with all the leaves intact, which may be termed normal number of leaves. With Marsh grapefruit, 60 to 75 leaves per fruit grew as big as those with all the leaves. The

other Citrus they worked with showed that the fruits with 60 leaves developed as those with no defoliation at all.

MATERIALS AND METHODS

For convenience the study was divided into three sets, namely, Experiment I, II, and III. The procedure followed in each experiment is described separately as follows:

Experiment I.—During the 1934–35 fruiting season, five fruiting Carabao mango trees at Novaliches, Rizal [1] were selected for this study. These trees were blown down by the October, 1934 typhoon, but the conditions of the trees were normal. Scattered bearing twigs having fruits of almost the same age and ranging from 5 to 10 mm in thickness were labeled on each tree. Only the soundest fruit was left on each twig, the rest were all carefully removed. Weekly measurements were made of these fruits until they matured or dropped off prematurely. For this purpose, white cardboard ruled to millimeter square was employed. The cardboard was placed behind and as close as practicable to the fruit and the reading was noted. By this method, unnecessary injuries on the fruits which otherwise might have caused the premature falling of the fruits was avoided.

The number of leaves for each of the variables ranged from zero to 25 per fruit, counting the leaves from the tip of the twig. Thus, the twigs with one fruit each were defoliated as follows: 0, 5, 10, 15, 20, and 25 leaves per fruit. Each variable was replicated at least four times on each of the five trees. In other words, there were at least 20 fruits measured for each variable, except where there were no sufficient suitable fruits available as in the case of 25 leaves per fruit. The twigs were not ringed or girdled, but the excess leaves were removed so as to limit the number of leaves supporting a fruit (see fig. 2). In case the number of leaves required for the fruit was insufficient, the leaves of the next lower shoot were used. There were 25 fruits used as control, that is, five fruits on each tree used.

As the size of mango leaves vary considerably, two sets of leaves of the same number may differ in areas. It was therefore necessary that the leaves required for the development of a mango fruit be expressed in terms of total leaf-area per fruit.

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[1] This mango plantation is owned by Dr. Nicanor Jacinto. It was previously leased to the Bureau of Plant Industry for experimental purposes.

This was made feasible by the use of a planimeter. In doing this, exact prints of the leaves were first made by pressing the leaves on paper after smearing dilute aqueous solution of light green on their surfaces. In some cases, the outlines of the leaves were obtained by pressing the leaves flat on the paper and then tracing the edges with the use of a pencil. In other cases, to facilitate the work, the use of photographic negatives was resorted to. The leaves were held flat on the negative by placing them between two pieces of glass and then exposing them to the light. By this method exact prints of the leaves were obtained. The areas of the prints were then measured by the planimeter as already mentioned above.

Experiment II.—This experiment was carried on a single tree in the mango orchard of the Lamao Horticultural Station, Limay, Bataan, during the 1934–35 fruiting season. The method employed here was practically the same as in Experiment I, except that instead of removing only the excess leaves, a girdle was made just below the required number of leaves (see fig. 1). The ring or girdle was as wide as the diameter of the twig. It was considered that the girdle was necessary to confine as much as possible the effect of the leaves under study and to limit the support of the fruit under Experiments I and II. No treatment was given the girdles inasmuch as there was not much loss of sap, the wound having dried after an hour or so from the time the girdle was made.

The variables studied were 5, 10, 15, 20, 25, 30, 35, 40, and 50 leaves per fruit. Ten fruits were originally labeled, treated and measured for each variable. In addition, ten fruits or practically the same size and condition as those above were used as control. The leaves used in the control were indefinite in number, i. e., not a single one was removed as they occurred in the tree. The control aims to find the normal size of the fruit under natural conditions.

In cases where there were more than one fruit in a panicle and both of them were used in the observation, the corresponding number of leaves for the variable under consideration was used, that is, if two fruits were on the same panicle and 15 leaves were desired for each fruit, the ring was made below the thirtieth leaf from the tip of the bearing twig. In case one of the fruits fell off during the course of the experiment, the leaves assigned to the fallen fruit were removed to maintain the required condition.

Measurements of the fruits were started as soon as they attained the size of a thumb or about five weeks after the fertilization of the flowers. The widths, lengths and thickness of the fruits were recorded weekly until they dropped off or harvested.

Experiment III.—This experiment was more or less a repetition of Experiment I and II. It was carried during the 1935–36 fruiting season at the Lamao Horticultural Station, Limay, Bataan. Five trees were selected for this experiment. The trees were approximately of the same age, size, vigor and were grown under similar soil and climatic conditions. The shortest distance between the trees was 12 meters. Fruits for each variable were selected from the different trees, and care was taken so as to have each variable uniformly represented on each tree. The fruits selected were located on all sides of the crown, as north, east, south and west.

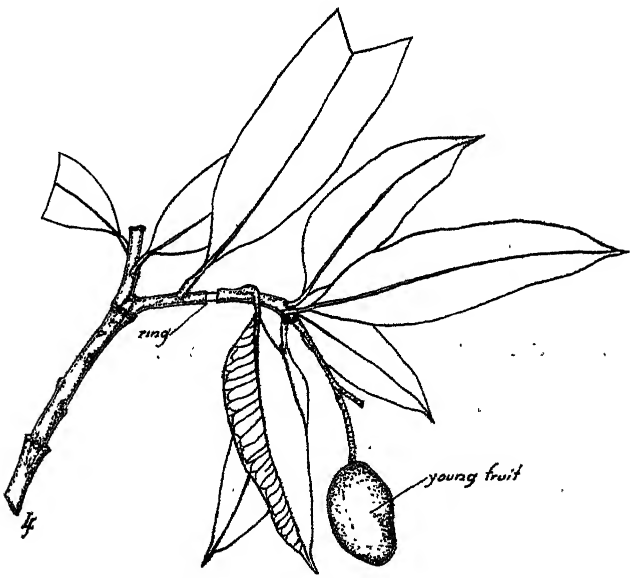

FIG. 1. A sketch of a Carabao mango bearing twig showing the ring or gridle.

In this experiment girdling as well as defoliating the twigs as a means of limiting the number of leaves per fruit of each of the variable was carried. In the defoliating method, the excess leaves down to the nearest twig were removed (see fig. 2). In some cases, it was also necessary to thin the excess number

of fruits to conform with the required number of leaves present on the twig.

In this experiment, greater number of individual fruits were studied. Twenty-five fruits each were used for the girdling and the defoliating methods, or a total of 50 fruits for each of the variables, 0, 5, 10, 15, 20, 25, 30, 35, 40, 50 leaves and the check.

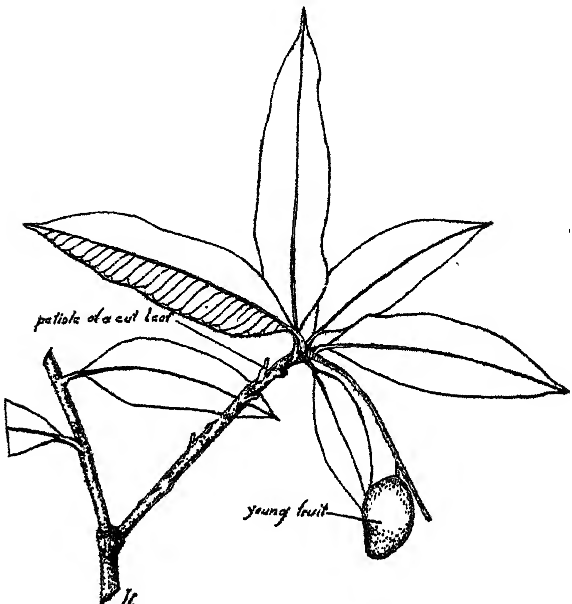

FIG. 2. A sketch of a Carabao mango bearing twig showing the petioles of the cut leaves

Measurements of the fruits were started as soon as they were a few millimeter thick. The length, width and thickness of each fruit under observation were recorded at weekly intervals until they dropped off prematurely or until ready for harvest in the case of those that remained.

Immediately after harvesting, the weights of the individual fruits were taken. As soon as the fruits ripened, they were studied in a more or less general way as regards appearance, color of flesh, sweetness and general quality.

In spite of all the possible care taken in the selection of the fruits for experiment, still a few of the fruits and some of the leaves dropped off during the course of the study. Such dropping somehow interferred in the outcome of the experiment.

TABLE I.—*Showing the data obtained during the 1934–35 fruiting season of Carabao mango at Novaliches, Rizal*

Number of leaves per fruit	Leaf-less	5-leaves	10-leaves	15-leaves	20-leaves	25-leaves	Control
Original number of fruits	20	20	20	20	20	4	25
Number of harvested fruits	15	14	14	16	13	4	15
Approximate age of fruits at maturity in days	42–63	42–63	42–63	42–63	42–63	56–63	35–63
Leaf-area per fruit in sq. cm	----------	261.430	478.670	665.940	1,072.940	1,386.875	Indefinite
Fruit size index in sq. cm	67.109	62.961	65.259	69.582	77.829	75.870	68.753
Fruit growth index in sq. cm	31.465	25.603	29.085	31.286	39.204	59.151	37.792

TABLE II.—*Showing the data during the 1934–35 fruiting season of Carabao mango at the Lamao Horticultural Station, Limay, Bataan*

Number of leaves per fruit	5-leaves	10-leaves	15-leaves	20-leaves	25-leaves	30-leaves	35-leaves	40-leaves	50-leaves	Control (Indefinite Number of leaves)
Original number of fruits	10	10	10	10	10	10	10	10	10	10
Number of harvested fruits	3	6	7	3	8	7	6	4	4	7
Approximate age of fruits at maturity in days	63	35	35–63	35–63	42–63	35–63	63	42–63	35–63	35–63
Fruit size index in cu. cm	133.23	424.79	180.81	396.83	277.53	262.29	316.96	580.18	433.21	593.31
Fruit growth index in cu. cm	6.22	45.04	8.42	73.75	25.90	34.92	59.68	111.66	86.11	126.41

TABLE III.—*Showing the data during the 1935–36 fruiting season of Carabao mango at the Lamao Horticultural Station, Limay, Bataan*

Number of leaves per fruit	Number of leaves up to nearest twig	5-leaves		10-leaves		15-leaves		20-leaves		25-leaves	
		Thinned	Ringed	Thinned	Ringed	Thinned	Ringed	Thinned	Ringed	Thinned	Ringed
Original number of fruits	25	25	25	25	25	25	25	25	25	25	25
Number of harvested fruits	21	13	2	9	6	5	4	10	10	11	5
Approximate age of maturity in days	56–63	56–63	49–63	56–63	56–63	56–63	63	56–63	56–63	63	63
Leaf-area per fruit in sq. cm	....	308.65	276.20	611.50	478.80	755.25	840.90	1,060.20	1,053.60	1,228.50	1,165.00
Fruits size index in cu. cm	417.79	555.88	193.65	470.32	108.73	532.28	153.87	416.39	180.41	449.92	209.01
Fruit growth index in cu. cm	154.26	381.85	102.54	336.07	30.15	323.65	67.77	219.79	76.79	273.25	93.60
Average weight of harvested fruits in grams	293.6	319.0	117.5	272.7	60.00	310.00	91.3	249.2	111.3	259.6	130.00

Number of leaves per fruit	30-leaves		35-leaves		40-leaves		50-leaves		Indefinite number of leaves (control)
	Thinned	Ringed	Thinned	Ringed	Thinned	Ringed	Thinned	Ringed	
Original number of fruits	25	25	25	25	25	25	25	25	50
Number of harvested fruits	6	9	11	14	11	9	12	10	27
Approximate age of maturity in days	56–63	56–63	56–63	63	56–63	63	56–63	56–63	63
Leaf-area per fruit in sq. cm	1,534.20	1,516.20	1,935.85	1,959.30	1,866.40	1,835.60	2,218.00	2,386.50	....
Fruits size index in cu. cm	346.32	287.22	477.29	311.88	445.69	304.14	433.89	341.89	487.20
Fruit growth index in cu. cm	168.12	120.20	246.71	139.82	235.23	124.59	188.25	141.22	190.31
Average weight of harvested fruits in grams	210.0	175.6	280.0	183.9	256.5	177.20	258.8	202.9	287.4

TABLE IV.—*Showing the average weight of fruits in grams of the Ringing Experiment from the different direction in the Crown*

Number of leaves	East	North-east	North	North-west	West	South-west	South	South-east
5 leaves	160.0	------	------	75.0	------	------	------	------
10 leaves	120.0	------	30.0	------	------	------	------	------
15 leaves	90.0	115.0	50.0	110.0	------	------	------	------
20 leaves	------	102.5	137.5	80.0	------	------	132.5	65.0
25 leaves	65.0	95.0	------	------	------	190.0	110.0	------
30 leaves	155.0	60.0	150.0	------	------	186.7	240.0	------
35 leaves	------	------	188.3	135.0	188.3	130.0	247.5	120.0
40 leaves	------	210.0	------	215.0	170.0	------	158.0	------
50 leaves	------	266.7	130.0	------	85.0	------	------	202.5
Total	590.0	849.2	685.8	615.0	443.3	506.7	888.0	279.5
Average	118.0	141.5	114.3	123.0	(147.7)	(168.9)	(177.6)	93.2

The data presented are those taken from fruits which were harvested and those that fell off just a week before harvesting.

RESULTS

The results of the experiment are given in summarized forms in Tables I to IV. They show the average growth, size and weight of Carabao mango fruits supported by varrying number of leaves. In table I, the size of the fruits is expressed in square centimeters while in Tables II and III, in cubic centimeters. The areas of the leaves are given in square centimeters.

Table I consists of the data obtained during the 1934–35 fruiting season at Novaliches, Rizal, while Table II indicates those obtained from the Lamao Horticultural Station at Limay, Bataan, during the 1934–35 fruiting seasons. Table III gives the 1935–36 results of defoliating and ringing the twigs as a means of limiting the number of leaves sustaining a fruit. Table IV presents the average weights in grams of fruits from the ringed lots situated at different directions in the crown of the trees.

DISCUSSION OF RESULTS

As shown in Table I, the size of the fruits increased as the number and areas of leaves increased up to 20 leaves per fruit, (Chart I, Table I fruit size index). The fruits with 5 leaves, having an area of 261.430 sq. cm. showed an average size of 62.961 sq. cm.; those with 10 leaves or with 478.67 sq. cm. leaf-area, averaged 65.259 sq. cm. in size; while those with 15 leaves with an area of 665.94 sq. cm. and 20 leaves with 1,072.94 sq. cm. leaf-area averaged in size 69.582 and 77.829 sq. cm., respectively. The fruits with 25 leaves or with a leaf-area of 1,386.875 sq. cm. showed an average size of 75.87 sq. cm., whereas those of the controls, were intermediate in size between the fruits having 10 and 15 leaves, respectively.

In Table I, it is apparent that the average total growth index increased with the number of leaves up to a certain limit, thus fruits with 5 leaves showed a total growth index 25.603 sq. cm. and those with 10 leaves, 29.085 sq. cm., while those with 15, 20, and 25 leaves gave 31.286, 39.204, and 59.151 sq. cm., respectively. The controls gave 37.792 sq. cm. average total growth index.

Further examination of Table I shows that the fruits without leaves reached an average size of 67.109 sq. cm. and a total growth index of 31.465 sq. cm. In other words, the fruits born on a leaf-less twig were bigger than those with 5 and 10 leaves, and they gave a greater growth index than the fruits having 5, 10, and 15 leaves. The results, therefore, apparently suggest that the fruits were able to depend upon the leaves remaining on the twigs or even upon those on the neighboring twigs (5).

Table II (see Chart I of Table II, fruit size index), shows that the control fruits, that is, those supported by as many leaves as naturally present on the trees attained the biggest size which was 593.31 cu. cm., followed by those with 40 leaves with the average size of 580.18 cu. cm. The third largest fruits were those with 50 leaves, with an average size of 433.21 cu. cm. The smallest fruits were obtained from those with 5 leaves to a fruit, the average size being only 133.24 cu. cm.

The lot with 10 leaves each fruit attained an average size of 424.79 cu. cm. Those with 15, 20, 25, 30, and 35 leaves per fruit reached varying sizes but smaller than those with only 10 leaves each. These irregularities seem inevitable when conditions surrounding the experiment are considered. For instance, the position, location, exposure and the age of the leaves should be taken into account. These factors no doubt influenced the photosynthetic activities of the leaves (1), thus helping determine the ultimate size of the fruits. Had it been possible to have every attending factor under perfect control, there might have been a gradual decrease of the size of the fruits from indefinite number of leaves down to five leaves per fruit. At any rate the general trend of the results of the experiment as graphed in Chart I, (Table II fruit size index and fruit growth index) suggests that in mango, the more the leaves that support a fruit, the bigger size the fruit may attain. The irregularities in the curve, particularly at 10 leaves and 20 leaves were probably due to the premature falling of the fruits and comparatively more advance size of the fruits at the start, as in the case of 10 leaves per fruit. Had all the fruits reached maturity, perhaps the curve would have been more regular. For example, in the case of 20 leaves (Table II), it may be said that the fruit that reached maturity was robust and was above the average fruits in vigor. As may be deduced from Table II, there were quite a number of premature falling of fruits, taking into account that the orig-

inal number as 10 for each lot. Thus, with 5 leaves, 7 fell; 10 leaves, 4; 15 leaves, 3; 20 leaves, 9; 25 leaves, 6; 30 leaves, 3; 35 leaves, 4; 40 leaves, 6; 50 leaves, 6; and control 3 fruits fell.

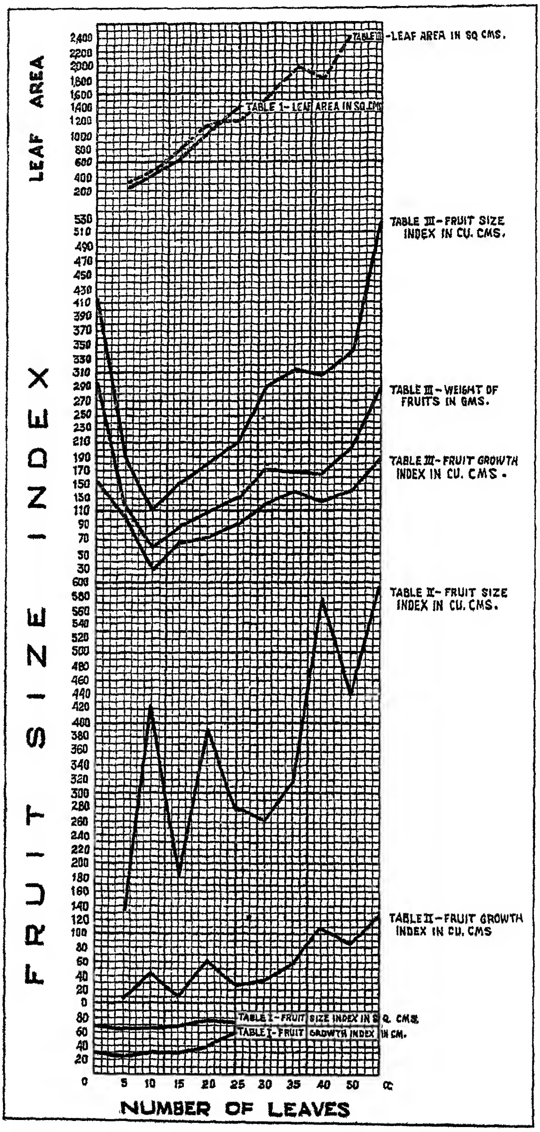

CHART 1. Showing the fruit size index, the growth and the weight of the fruits together with the corresponding leaf areas of the girdled twigs.

From Table II, (see also Chart I) it may be noted that the average total growths followed almost the same trend as the total size of the fruits. The fruits with all the leaves intact, gave a growth index of 126.41 cu. cm., followed by 40 leaves with 111.66 cu. cm., then 50 leaves with 86.11 cu. cm. came next, and the fruits with 20 leaves came in as fourth, giving a growth index of 73.75 cu. cm.

The results indicate that 40 leaves to a fruit were enough to produce fruits almost equal in size with those produced with all the leaves.

Considering the two methods of limiting the number of leaves per fruit (Table III), it is evident that ringing the twigs produced in all cases much smaller fruits than those of the thinned lots. Apparently, ringing rendered the isolated portion independent from the other parts of the plant, to a certain extent, especially so as regards manufactured food supply(2). This possibility becomes more apparent when the fact that fruits on totally defoliated but not girdled twigs, developed fully and in some cases were even bigger than others with leaves, is considered. In this case there was an apparent dependence of the fruits for support from the lower leaves.

With thinning or defoliating as a method, the data show that the lot with five leaves per fruit were the largest, the heaviest and made more growth than the fruits with a greater number of leaves each. As a whole, the results of thinning the leaves gave inconsistent gradation of sizes of fruits from the different variables used. With the ringing or girdling method, the size, rate of growth and weight of fruits with 15, 20, 25, 30, and 35 leaves followed a regular and a more or less smooth upward trend as in the areas of leaves (see Chart I, graphs of Table III). These graphs show that the size, growth and weight of the fruits of the girdled twigs, having 5 leaves and 35 leaves to the fruit, were somewhat abnormally high to distort the curve. This was due perhaps to premature falling of fruits as already explained elsewhere in this paper. For instance in the case of 5 leaves per fruit lot, only two out of 25 fruits studied survived the treatment, so it may be said that the two fruits had superior strength and vigor. Regarding the distortion of the curve by the 35 leaves per fruit lot, it should not be taken as irregularity and contradictory to the general trend of the results of the study, for in fact it served as another sustaining proof that taking other conditions equal, the more leaf-area supporting a mango

fruit, the more nearly the fruit reached its greatest development. In this particular case the leaf-area of the 35 leaves was greater than that of the 40 leaves (see Table III).

The fruits with indefinite number of leaves (control) were largest and heaviest and they made the most growth among the (ringed) lots. This, however, did not hold true in the case of thinning method.

With defoliation, the largest fruits were found with the 5 leaves (area—308.65 sq. cm.) lot. The fruits with leaf-areas 2,218.00 sq. cm. (50 leaves), 1,935.85 sq. cm. (35 leaves) and 1,866.40 sq. cm. (40 leaves) were the next biggest in the order of their enumeration and they were 433.89, 477.29 and 445.69 cu. cm., respectively. The fruits with an indefinite number of leaves each, had an average size of 487.20 cu cm.

As regards the general appearance and quality of fruits, those supported by 5 leaves (ringing method) were generally abnormal in form, and the flesh was not so sweet. The seeds appeared sound. The fruits supported by 10 leaves were very much better in taste. The flesh was rich yellow, sweet and of excellent flavor. They matured more uniformly and earlier. The fruits supported by 15 leaves and upwards, that is, 20 leaves to indefinite number (control) were more or less similar to those with 10 leaves. However, their dates of maturity were irregular and generally later. It seems likely that a Carabao mango fruit requires at least 10 leaves for its fair development as to quality.

It was mentioned elsewhere in the paper that the position of the leaves and their degree of exposure to sunlight each day during fruit development may play an important role in the ultimate size of fruits. The results of Experiment III (ringing method) apparently suggest some effect of light duration on the weight of the fruits (Table IV).

The data, however, are averages of several variable, i. e., 5 leaves, 10 leaves, 15 leaves, etc. as this consideration was only taken as coincidental with the study.. Moreover, it was rather impossible to locate fruits on the crown of the trees that are uniformly distributed as regards directions. For this reason the available fruits were divided into lots according to their location on the tree and variously treated according to the principal objectives of the study. The average weights of the fruits were considered. Thus, fruits located at the east side of the crown

had, under this condition, an average weight of 118.0 grams, those on the northeast, 141.5 grams, those on the north 114.3 grams, those on the northwest, 123.0 grams, those on the west, 147.7 grams, those on the southwest, 168.9 grams, those on the south 177.6 grams and lastly those on the southeast weighed 93.2 grams.

It may be seen from the above, that fruits located south, southwest and west were the heaviest among the entire lots. This may be due to the influence of light duration as the sun traveled along this path during that time of the year. This was similar to the findings of Shamel and Pomeroy on their work on Citrus, that the length of daily exposure of leaves to sunlight influenced the development of the fruits. Our results are too meager, but are suggestive of this tendency of fruit development. Nevertheless, it should not be mistaken as conclusive but certainly it serves a good invitation to a pomological problem for other students to work out more systematically.

SUMMARY

1. The paper presents the results of studies on the influence of the number or area of leaves on the growth, size and quality of mango fruits.

2. Two methods, namely, defoliating the leaves and girdling the twigs, to limit the number of leaves to support a mango fruit is presented.

3. The defoliating method for establishing the required number of leaves per fruit gave variable and inconsistent results, while ringing furnished a more uniform and consistent data. The difference in the two methods was due perhaps to interdependence of the different twigs as regards food supply which was possible in the case of the thinning method, but which was rather remote in the girdling method.

4. Based on the results obtained from the girdling method, the growth, size, weight and quality of Carabao mango fruits were influenced by leaf-area supporting it.

5. Generally the fruits on the girdled twigs were smaller than those on the defoliated twigs, especially if the girdling was made nearer the fruit, or with less number of leaves above the girdle.

6. Fruits supported by a greater number of leaves showed a tendency towards irregular and later maturity.

7. The weights of fruits seemed to depend partly on light duration.

8. The data presented in the paper show that 10 leaves were sufficient to support a fruit to a satisfactory quality. Beyond 50 leaves per fruit, the limit used in the experiment, was necessary to develop a good sized Carabao mango fruit, although, 30 to 50 leaves per fruit were considered satisfactory. In general the results indicated that the more leaves supporting a mango fruit, the greater are the chances for the fruit to attain a bigger size. It seems probable that cultural practices in mango orchards could be so modified as to promote or maintain a considerable number of leaves on the tree to insure the perfect development of the fruits.

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ILLUSTRATIONS

TEXT FIGURES

PROGRESS REPORT OF CABBAGE EXPERIMENTS AT BAGUIO, MOUNTAIN PROVINCE[1]

By M. E. GUTIERREZ

Of the Baguio Plant Industry Experiment Station

INTRODUCTION

Cabbage, *Brassica oleracea,* is the most important vegetable grown at the Baguio Plant Industry Experiment Station. In fact, it ranks first as a truck crop in all Baguio and the Trinidad Valley. The cabbage industry has had a remarkable growth, encouraged and hastened by the influx of keen and skillful Japanese and Chinese gardeners, and it would seem that lack of more suitable land is the only limit to its further extension. Cabbage hectarage surpasses that of any or that of all other truck crop grown. So that now, the Trinidad-and Baguio-grown cabbage not only supplies the ever growing large Baguio market, but also the large surplus finds its way to many parts of the country, principally in Luzon and some parts of the Visayan Islands.

Although our cabbage crop, does not show extra large heads as produced by commercial gardeners in the two places, it is the favorite among fastidious people of Baguio. Among the hosts of cabbage gardens, the station cabbage is recipient of this unique distinction: Americans and Europeans are not afraid to eat it raw, due to its pronounced quality and cleanliness, the latter factor being due to the exclusive use of complete commercial fertilizers in its production.

This station conducts cabbage experiments, principally on the following lines of investigation: regular and rainy season variety tests of American and English seeds, experiments with fertilizers, using commercial fertilizers, and cultural methods. The following pages report in a preliminary way the progress being accomplished with five different experiments.

VARIETY TESTS

Variety tests of cabbage have been continuously conducted at this station, in order to find out the best varieties to plant either for the rainy or regular seasons. So far, we were unable to carry through for several seasons with the same va-

[1] Thanks are due to Mr. Feliciano Domine, Plant Propagator, for his valuable help during the progress of these experiments.

rieties, due either to lack of seeds of the specific varieties tested or insufficient sound seedlings at planting time. In the latter case, our seedlings are not all grown in glasshouses, as they should be in this cold region, for lack of adequate glasshouses for the purpose, and often we cannot get enough good seedlings from our open seedbeds to run the necessary replicated plots. During the rainy season of 1935 and the regular seasons of 1935–36 and 1936–37, three series of variety tests were conducted and which are reported successively.

I. RAINY SEASON VARIETY TESTS OF CABBAGE, 1935

It is the universal belief among gardeners of Baguio and the Trinidad Valley that the only variety of cabbage which can be successfully grown during the rainy season is the Shanghai cabbage. This is a large, late variety, but with soft head and of poor quality. As these gardeners grow cabbage the year round, during the rainy season here, June to October, only this variety is grown.

Objects.—The objects of this experiment were to verify the reason for the preference of these gardeners for the Shanghai variety for rainy season planting, to find other varieties of better quality for this season, and whether it is profitable to grow cabbage during this off-season for vegetables.

Time and place.—This study was conducted during the rainy season of 1935. This, and all the other experiments reported herein were conducted at the Baguio Plant Industry Experiment Station, Baguio, Mountain Province.

It should be remarked that this work was carried out during the worst rainy season in Baguio with unabated rains, often torrential, floods, and storms, such as rarely happens in the locality. The only bad weather that could approach it was that of 1911. The rainfall record during the progress of this study was as follows:

	Millimeter
June	243.4
July	330.2
August	2,346.9
September	597.4
October	223.0
November	860.0
Total	4,600.9 mm.

Materials and methods.—Seeds of ten (10) varieties to be enumerated presently, which served as the different variables

of this experiment were sown on June 13, 1935 in our small glasshouse and in open beds.

A—Succession
B—Stein's Flat Dutch
C—Wisconsin Hollander
D—Surehead
E—Charleston or Large Wakefield
F—Early Winnigstadt
G—Enkhuizen Glory
H—All Head Early
I—Premium Flat Dutch
J—Shanghai (Check)

With the exception of Shanghai and early Winnigstadt, which germinated two days later, the seeds of the other eight varieties germinated on June 18.

On July 12, 22, and 25, the seedlings were sprayed first with 1 per cent lead arsenate solution and then again with Imazu-lead arsenate-soap solution (75 g.-80 g.-80 g in 20 l. of water), which was both a contact and stomach insecticide.

The field which was chosen for this experiment was free from floods and well drained. After a thorough preparation, it was converted into 40 equal-sized beds or plots of 1.10 m. by 10 m. with a path of 30 cm. each and including this corresponding canal or path, each covered an area of 14 sq. m. There were two columns of beds which were arranged as follows:

Before setting the plants in the beds, holes were made, spaced 50 cm. apart each way, in triangles, allowing 38 plants per bed. Into each hole one shovelful of compost and 35 grams of Nitrophoska IG No. 3 (16.5 N-16, 5P205-21.5K20) were applied and were mixed thoroughly with the loose earth. On August 13, the first two replications were planted in their corresponding beds with seedlings taken from the small glasshouse. The next day, the other two replications were planted with seedlings from the open and pricking beds. Due to the very bad weather suffered by these open-grown seedlings, especially during the period of July 29 to August 5, there were not sufficient sound seedlings to complete the planting of four replications. This report, therefore, is limited to three replications with 114 plants per variety.

Spraying of the plants uniformly for all the beds were made at regular weekly intervals with the second solution mentioned.

In August 24 and September 23, the beds were cultivated with hand cultivators after top dressing with ammonium sulphate at the rate of 100 grams per bed each time.

Observations.—Close observations were made periodically with the different varieties with respect to their reaction to the prevailing weather conditions and to the diseases and pests which attacked them. The following varieties suffered from black-leg disease, *Phoma lingam:* Succession, Stein's Flat Dutch, Surehead, Early Winnigstadt, and All Head Early. There were other deaths of plants, apparently due to soft rot or other undetermined diseases. The number of plants of each variety attacked and subsequently killed was as follows:

Succession	2 plants
Stein's Flat Dutch	3 plants
Wisconsin Hollander	2 plants
Surehead	6 plants
Charleston Wakefield	2 plants
Early Winnigstadt	9 plants
Enkhuizen Glory	4 plants
All Head Early	16 plants
Premium Flat Dutch	1 plant
Shanghai	none

It is seen that the Shanghai variety in this experiment was singularly free from diseases. It may be inferred from the above results that it is the most resistant to diseases among the varieties studied. In spite of the strong rains, storms, and weekly sprayings, all the cabbage varieties suffered from the ravages of pests.

In general, it was noted that the plants were somewhat slow in heading and coming to maturity. The dates for each variety were noted for the maturity of the first and the last head, as follows:

A—Succession: October 19 to November 16.
B—Stein's Flat Dutch: October 22 to November 25.
C—Wisconsin Hollander: November 3 to December 6.
D—Surehead: October 23 to November 26.
E—Charleston Wakefield: October 19 to December 6.
F—Early Winnigstadt: October 22 to November 18.
G—Enkhuizen Glory: October 22 to December 6.
H—All Head Early: October 22 to November 25.
I—Premium Flat Dutch: November 3 to December 6.
J—Shanghai: November 14 to December 6.

Results.—Harvest was made by priming at fairly regular intervals. The results are consolidated in the following table:

TABLE 1: 1935.—*Rainy season results of cabbage experiment, showing the number of marketable heads, yield in kilos produced, and average yield, per bed, per cent headed, calculated yields per hectare in kilos and value thereof, and gain or loss per hectare.*

	A—Succession			B—Stein's Flat Dutch			C—Wisconsin Hollander		
	Plot	Headed	Yield	Plot	Headed	Yield	Plot	Headed	Yield
	1A	31	16.70	2B	24	18.84	3C	14	3.54
	11A	13	2.86	12B	22	7.96	13C	4	0.50
	29A	8	2.22	30B	14	4.36	31C	4	1.04
		52	21.78		60	31.16		22	5 08
Average per bed		7.27+3.20			10.387+2.83			1.693+1.40	
Per cent headed		45.6			52.6			19.3	
Calculated yield per hectare		5,283.6			7,416.3			1,208.8	
Value[1]		₱1,056.72			₱1,483.26			₱241.76	
Experiment of production		₱1,035.96			₱1,035.96			₱1,035.96	
Gain or loss		₱20.76			₱447.30			—₱794.20	
	D—Surehead			E—Charleston Large Wakefield			F—Early Winnigstadt		
	4D	37	16.90	5E	30	11.30	6F	24	6.90
	22D	29	8.70	15E	22	9.70	16F	9	2.38
	32D	23	7.52	23E	9	1.96	24F	15	3.92
		89	33.12		61	22.96		48	13.20
Average per bed		11.04+1.75			7.85+1.82			4.40+0.87	
Per cent headed		78.0			53.5			42.1	
Calculated yield per hectare		7,882.5			5,504.9			2,896.4	
Value		₱1,576.50			₱1,100.98			₱579.28	
Experiment of production		₱1,035.96			₱1,035.96			₱1,035.96	
Gain or loss		₱540.54			₱65.02			—₱456.68	

TABLE 1: 1935.—*Rainy season results of cabbage experiment, showing the number of marketable heads, yield in kilos produced, and average yield, per bed, per cent headed, calculated yields per hectare in kilos and value thereof, and gain or loss per hectare*—Continued.

	G—Enkhuizen Glory			H—All Head Early			I—Premium Flat Dutch			J—Shanghai (Check)		
	7G	28	9.08	8H	32	14.88	9I	17	4.54	10J	26	9.66
	17G	10	2.64	23H	23	8.48	19I	7	1.94	20J	22	5.06
	25G	20	8.02	36H	14	5.22	27I	12	2.60	28J	23	7.70
		58	19.74		69	28.58		36	9.08		71	22.42
Average per bed		6.58+1.28			9.53+1.82			3.03+0.51			7.47+0.81	
Per cent headed		50.9			60.3			31.6			62.3	
Calculated yield per hectare		4,698.1			6,804.4			2,163.4			5,333.6	
Value		₱939.62			₱1,360.88			₱432.68			₱1,066.72	
Experiment of production		₱1,035.96			₱1,035.96			₱1,035.96			₱1,035.96	
Gain or loss		—₱96.34			₱324.92			—₱603.28			₱30.76	

[1] At ₱0.20 per kilo wholesale.

Interpretation of results.—Were the weather conditions normal during the progress of this study, it is probable that the varieties would have given a better account of themselves.

The fact should be stressed that our expenses on the hectare basis were somewhat high, because based on experimental basis and secured in an abnormal weather. The Nitrophoska basic fertilizer used was expensive at ₱190 per ton including transportation and is not known as the best fertilizer for cabbage with our soil conditions.

Moreover, for the lack of an adequate glasshouse, the seedlings used were not all equally sound. Our observations for several seasons in Baguio were convincingly in favor of glasshouse-grown seedlings.

It is clear from the above table that in spite of untoward weather conditions with a rainfall of 4,600 mm. during the period covered in this study and the above-mentioned limiting factors six varieties turned out successful, and consequently profitable; namely, Surehead, Stein's Flat Dutch, All Head Early, Charleston Wakefield, Shanghai, and Succession. The first three named varieties showed outstanding results. Shanghai, however, was in the fifth place among the six, but showed slightly superior results to Succession.

As the Shanghai served as check, the relative yields in percentage of the other varieties as compared to it were as follows:

Surehead	148
Stein's Flat Dutch	139
All Head Early	127
Charleston Wakefield	103
Shanghai (Check)	100
Succession	99
Enkhuizen Glory	88
Early Winnigstadt	54
Premium Flat Dutch	41
Wisconsin Hollander	23

The yields registered by the successful varieties in this experiment were one-half to one-third lower than their normal production during the regular season. The all important question arises whether with these depressed yields, it is worthwhile growing cabbage during the rainy season. The answer is in the affirmative with highly adapted varieties for this season, shown in the above table, because the cabbage price during the rainy

season soars two to three times above the price levels during summer. During the summer abundance of cabbage, the price is eight to ten centavos per kilo; on the other hand, during the rainy season the price is from twenty to thirty centavos per kilo, brought about by the small supply and the greater efforts necessary for production.

While the Shanghai did not show the best results in this work, slightly better than Succession, the remarkable fact that during the rainy season it was singularly free from diseases, and consequently the most resistant, may explain the preference of the gardeners for it. It is a fact that during the rainy season the incidence of diseases is more serious than in the regular season and the fear that any of these diseases may acquire virulence, nullifying the crop, hence their reliance to this resistant variety for off-season growing.

SUMMARY

1. A rainy season variety experiment consisting of ten varieties with Shanghai as check, was conducted at Baguio during the rainy season of 1935.

2. The Shanghai is not the only cabbage variety, which can be grown successfully during the rainy season in Baguio. The varieties Surehead, Stein's Flat Dutch, All Head Early, and Charleston Wakefield showed better result, notably the first three.

3. Shanghai was singularly free from diseases in this experiment, which fact shows it to be the most resistant among the varieties studied, hence the preference of the gardeners in planting it exclusively during the rainy season.

4. The following varieties were found not adapted for rainy season plantings: Enkhuizen Glory, Early Winnigstadt, Premium Flat Dutch, and Wisconsin Hollander.

5. It is profitable, but with incident risks, to grow cabbage varieties during the rainy season, as shown by six of the ten varieties studied.

II. VARIETY TESTS OF CABBAGE, 1935–36 REGULAR SEASON

SERIES 1

During the 1935–36 regular cabbage season a set of six, mostly new varieties, was tried for test.

Materials and methods.—Seeds of the varieties mentioned hereunder and serving as variables for these tests were sown separately in open beds on November 12, 1935.

A—Special Succession
B—Danish Ballhead
C—Early Winnigstadt
D—Penn State Ballhead
E—Burpee's Succession
F—Burpee's Surehead

One of the best of the station level fields, was chosen for these tests. After the ground was put in excellent tilth, it was converted into 18 even-sized beds or plots, 1.2 m. by 10 m. with a path of 40 cm. One corresponding path was included in the area of each bed, making 16 sq. m. As there were 9 beds in each column, the varieties were arranged in such a way in order that each variety included different portions of the field for obvious reasons. The beds were arranged as follows:

10D	11E	12F	13A	14B	15C	16D	17E	18F
1A	2B	3C	4D	5E	6F	7A	8B	9C

In January 7–8, 1936, the seedlings of the six varieties were transplanted in their corresponding beds, spacing the plants 50 cm. each way, in triangles, allowing 38 plants per bed. For the three replications, 114 plants were required of each variety. Before setting the plants, each hill received one shovelful of compost and 25 grams of station fertilizer mixture No. 1 with the proximate composition of 10 N—15 P205—8K20. Two dressings of ammonium sulphate of 5 grams each per plant each time, were made on January 26 and on March 17, 1936.

The plants were sprayed uniformly with our standard Imazu-lead arsenate-soap solution at regular weekly intervals.

Likewise, cultivation, watering, and weeding were done uniformly for all the beds.

Results.—Harvests were carried out by priming, beginning March 21 and terminating April 4, 1936. The results of the harvests are consolidated and presented in table 2.

TABLE 2.—*First regular season variety test results with cabbage, showing number of plants heading and marketable, total yield for the three replications, average yield per plot in kilos and per head in grams, percentage headed, and calculated yields per hectare.*

	A—Special succession			B—Danish Ballhead			C—Early Winnigstadt		
	Plot	Headed	Yield	Plot	Headed	Yield	Plot	Headed	Yield
	1A	38	23.26	2B	27	13.10	3C	29	12.82
	7A	27	16.84	8B	13	4.46	9C	15	4.46
	13A	32	26.84	14B	23	12.50	15C	17	9.60
		97	66.94		63	30.06		61	26.88
Average per bed	22.313+1.89			10.02+1.82			8.96+1.55		
Average weight per head in grams [1]	690			477			440		
Per cent heading	85.0			55.3			53.5		
Calculated yield per hectare in kilos	13,945.6			6,262.5			5,600.0		
	D—Penn State Ballhead			E—Succession			F—Surehead		
	4D	24	13.82	5E	30	18.24	6F	36	16.68
	10D	17	6.90	11E	34	19.82	12F	30	16.68
	16D	29	9.46	17E	34	23.58	18F	36	27.66
		70	30.18		98	61.64		102	61.02
Average per bed in kilos	10.06+1.21			20.537+0.91			20.34+2.42		
Average weight per head in grams [1]	503			537			617		
Per cent heading	61.4			85.9			89.6		
Calculated yield per hectare in kilos	6,287.5			12,835.6			12,712		

[1] Calculated per replication, instead of total results of each variable.

Summary.—1. During the 1935–36 regular season, a variety tests of six cabbage varieties were conducted at Baguio.

2. In the order of yield, the six varieties stood as follows: Special Succession, Burpee's Succession, Burpee's Surehead, Penn State Ballhead, Danish Ballhead, and Early Winnigstadt.

3. It is remarkable that our first season results with the three outstanding varieties, Special Succession, Burpee's Succession and Burpee's surehead, follow closely the result obtained at lower altitudes at the Los Baños Economic Garden, Los Baños, Laguna and at the Central Experiment Station, Manila.[1]

4. In percentage of heading, the order was as follows: Surehead, Succession, Special Succession, Penn State Ballhead, Danish Ballhead, and Early Winnigstadt.

5. In the average weight per head, the six varieties stood in the order named: Special Succession, Surehead, Succession, Penn State Ballhead, Danish Ballhead, and Early Winnigstadt.

III. VARIETY TESTS OF CABBAGE, 1936–37 REGULAR SEASON

SERIES 2

As the seeds of the varieties of the first series just described were not available, these tests could not be repeated in the following season. Instead, the station received another set of eight varieties and the second series of variety tests was started.

Materials and methods.—On November 2, 1936, seeds of the following varieties, serving as variables for these tests were separately sown in our small glasshouse.

A—Succession.
B—Premium Flat Dutch.
C—Large Charleston Wakefield.
D—Improved All Head Select.
E—All Head Early.
F—Copenhagen Market.
G—Golden Acre.
H—Enkhuizen Glory.

After putting the field in excellent condition for planting, it was converted into 32 equal-sized beds, 1.1 m. by 10 m. with a path of 30 cm. Including this corresponding path or ditch, the area of each bed or plot was 14 sq. m. As all these 32 beds were in one column, the varieties were planted consecutively for every set of variables as listed above until the four replications were completed.

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[1] Annual Report of the Director of Plant Industry, 1936, page 75.

Holes were made 50 cm. apart each way, in triangles, allowing 38 plants per bed. Into each hole a shovelful of compost and 50 grams of station fertilizer mixture No. 3 with the proximate composition of 10 N—15 P205—10 K20 were mixed thoroughly with the loose earth in each hole.

On January 4–5, 1937, all the eight varieties were transplanted in the 32 beds. For the four replications there were 152 plants per variety.

Treatments, such as spraying at regular weekly intervals with the standard Imazu-lead arsenate-soap solution, cultivation, weeding, and watering by running water in the canals, were done uniformly for the 32 beds.

The dates of the maturity of the first and last head of each variety were noted and given hereunder:

A–Succession: April 16 to May 31.
B–Premium Flat Dutch: April 24 to May 31.
C–Large Charleston Wakefield: March 17 to May 3.
D–Improved All Head Select: March 23 to May 31.
E–All Head Early: March 21 to May 15.
F–Copenhagen Market: March 17 to May 15.
G–Golden Acre: March 17 to May 1.
H–Enkhuizen Glory: March 30 to May 31.

Results.—The results of the harvests are consolidated and presented in the following table:

TABLE 3.—*Second series of variety test results with cabbage, showing total number of plants heading and marketable and yield of four replications, average yield per bed in kilos, average weight per head in grams, per cent headed, and calculated yields per hectare.*

	A—Succession			B—Premium Flat Dutch			C—Large Charleston Wakefield			D—Improved All Head Select		
	Plot	Headed	Yield	Plot	Headed	Yield	Plot	Headed	Yield	Plot	Headed	Yield
	1A	4	1.60	2B	6	3.60	3C	1	0.96	4D	7	7.00
	9A	15	6.26	10B	19	8.68	11C	18	12.18	12D	30	20.18
	17A	27	17.58	18B	15	14.94	19C	25	14.94	20D	11	5.76
	25A	14	12.10	26B	21	15.90	27C	20	13.65	28D	26	21.30
		60	37.54		61	43.12		64	41.73		74	54.24
Average per bed		9.385+2.29			10.78+1.95			10.43+2.16			13 56+2.83	
Average weight per head in grams[1]		583			685			678			754	
Per cent headed		39.47			40.13			42.10			48.69	
Calculated yield per hectare in kilos		6,700.9			7,696.9			7,447.0			9,681.8	

	E—All Head Early			F—Copenhagen Market			G—Golden Acre			H—Enkhuizen Glory		
	Plot	Headed	Yield	Plot	Headed	Yield	Plot	Headed	Yield	Plot	Headed	Yield
	5E	20	14.90	6F	7	2.80	7G	17	7.54	8H	18	8.96
	13E	38	20.82	14F	26	15.70	15G	12	10.20	16H	15	11.80
	21E	26	21.20	22F	1	0.60	23G	20	10.70	25H	36	26.70
	29E	24	24.12	30F	15	6.96	31G	19	16.60	32H	27	22.18
		108	81.04		49	26.06		68	45.04		96	69 64
Average per bed		20.26+1.28			6.515+2.23			11.26+1.28			17.41+3.10	
Average weight per head in grams		557			516			662			711	
Per cent headed		71.09			32.37			51.32			62.50	
Calculated yield per hectare in kilos		14,465.1			4,851.7			8,039.6			12,430.7	

[1] Calculated per replication, instead of total results of each variable.

Summary 1.—During the 1936–37 regular season, a second series of cabbage variety tests, consisting of eight varieties, was conducted at Baguio.

2. With the eight varieties studied, the order of yield was as follows: E–All Head Early, H–Enkhuizen Glory, D–Improved All Head Select, G–Golden Acre, B–Premium Flat Dutch, A–Succession, and F–Copenhagen Market. The first three varieties, All Head Early, Enkhuizen Glory, and Improved All Head Select were outstanding in yield.

3. In weight of head, the eight varieties stood in the order named: D–Improved All Head Select, H–Enkhuizen Glory, B–Premium Flat Dutch, C–Large Charleston Wakefield, G–Golden Acre, A–Succession, E–All Head Early, and F–Copenhagen Market.

4. In percentage of heading and marketable heads, the varieties were in the following order: E–All Head Early, H–Enkhuizen Glory, G–Golden Acre, D–Improved All Head Select, C–Large Charleston Wakefield, B–Premium Flat Dutch, A–Succession, and F–Copenhagen Market.

5. It is to be noted that the order of yield per hectare follows very closely the order of the percentage of heading. In other words, a given variety of cabbage, other conditions being equal, with a large percentage of heading, showing high adaptability to local conditions, is a fair criterion of yield.

IV. CABBAGE FERTILIZER EXPERIMENT, 1936–37 SEASON

Baguio soil is very poor. In order to get a decent crop especially of vegetables, truck gardeners have to resort to heavy fertilization. Representative of this heavy manuring, the fertilizer practice of Trinidad Agricultural High School is quoted: [1]

> "In each hole 40 grams of Corona Especial (5 N– 8P205 –10 K20) 200 grams of ashes, 400 grams of well rotted manure or compost, 50 grams of fish meal and 50 grams of bean meal should be applied before planting. If fish meal and bean meal are not available the Corona Especial should be increased to 60 grams.
>
> "Two weeks after the seedlings are planted into the field ammonium sulphate is applied to each hill once a week either in solid form or liquid. If it is the solid form 5 to 10 grams of ammonium sulphate is dropped near the base of each plant and watered after application. The application should be continued for ten weeks for medium and early varieties and twelve weeks for late varieties."

[1] Vibar, H. N. and Llabres, M. Cabbage Growing in the Trinidad Agricultural High School, Agri. Life 111 (Nov. 1936) No. 11.

As this station uses chemical fertilizers, it is necessary to find the best and most profitable commercial fertilizer for cabbage—our second most important crop.

This paper presents the preliminary results of fertilizer experiment carried out during the regular cabbage season of 1936–37.

Materials and methods.—The land used for this experiment is low and of silty loam. The layout of the 32 beds, their number, their size (1.1 m. by 10 m. with 30 cm. path), the number of plants per bed (38) or 152 plants for the four replications, and the date of sowing the seeds (Nov. 12, 1936) were similar to the previous tests. The only variations were the use of the Large Charleston Wakefield variety only and the fertilizer treatments. There were eight variables in this experiment replicated four times each. The fertilizer treatments were as follows:

A—Ammophos plus sulphate of potash (20 N–20P205–8K20)
B—Ammophos (20N–20P205–0K20)
C—Leunaphos No. 2 plus sulphate of potash (16.5N–20P205–8K20)
D—Station Mixture No. 1 (10N–15P205–8K20)
E—Station Mixture No. 2 (10N–8P205–6K20)
F—Station Mixture No. 3 (10N–15P205–10K20)
G—Fertilica (10N–10P205–24K20)
H—Check (No fertilizer)

Holes 50 cm apart each, in triangles, were dug in each bed. Into each hole a shovelful of compost and 50 grams of the corresponding fertilizer were placed and both mixed thoroughly with the loose earth. The fertilizers were applied at the rate of one and one-fourth ton per hectare. For obvious reasons, the beds were not dressed with ammonium sulphate.

Seedlings of Large Charleston Wakefield were transplanted in January 5–6, 1937.

With the exception of the different fertilizer treatments, all the different field operations, such as spraying with the standard Imazu-lead arsenate-soap solution, weeding, cultivation, watering by canal irrigation were uniform for all the 32 beds.

Observations.—There were noted differences in the various treatments in the development of the plants, the size of plants, the heading propensity, brought about by the reaction of the plants to the specific fertilizers used.

There was a patent variation in heading. The replicated plots of Fertilica, Ammophos plus sulphate of potash, Leunaphos No. 2 plus sulphate of potash, and the station fertilizer mixture No. 1 produced more heads of cabbage than the other treatments.

There were also differences noted among the different fertilizer treatments with respect to the maturity of the cabbage. The earliest harvest was obtained on March 22, 1937, from the C–Leunaphos No. 2 plus sulphate of potash beds, followed by the G–Fertilica plots, the A–Ammophos plus sulphate of potash beds, the B–Ammophos, the F–station mixture No. 3, the D–station mixture No. 1, and E–mixture No. 2 in succession. The unfertilized or check plots yielded the latest, over a month after the first beds produced matured heads.

From ocular observations, the size of the heads of the different treatments varied. The check plots produced the smallest heads.

Results.—Harvest of the different replicated beds was done by primming. The first harvest was made on March 22 and ended for all the experiment on June 26, 1937. The results of the tests are consolidated on the following table:

TABLE 4.—*Fertilizer experiment results with cabbage showing number of marketable heads and quantity in kilos produced per bed, average yield per bed, average weight in grams per head, per cent headed calculated yield per hectare in each treatment, value thereof, expense per hectare and gain or loss for each fertilizer treatment.*

	A—Ammophos plus sulphate of potash			B—Ammophos			C—Leunaphos No. 2 plus sulphate of potash			D—Station fertilizer mixture No 1		
	Plot	Headed	Yield	Plot	Headed	Yield	Plot	Headed	Yield	Plot	Headed	Yield
	1A	32	20.40	2B	29	20.50	3C	30	18.88	4D	16	12.68
	9A	31	23.00	10B	24	18.20	11C	20	17.16	12D	31	28.30
	17A	27	20.46	18B	23	16.18	19C	26	19.86	20D	35	24.08
	25A	27	17.64	26B	18	10.62	27C	28	17.68	28D	16	9.70
		117	81.50		94	65.50		104	73.58		98	74.76
Average per bed		20,375+0.67			16.375+1.42			18.395+0.42			18.69+3.04	
Average weight per head in grams[1]		697			640			721			709	
Per cent headed and marketable		76.98			61.99			68.42			64.78	
Calculated yield per hectare in kilos		14,547.7			11,691.7			13,134.0			13,344.7	
Value at ₱0.10 per kilo		₱1,454.77			₱1,169.17			₱1,313.40			₱1,334.47	
Estimate expenses per hectare		₱874.56			₱872.65			₱879.80			₱779.31	
Gain or loss per hectare		₱580.21			₱296.52			₱433.60			₱555.16	

TABLE 4.—*Fertilizer experiment results with cabbage showing number of marketable heads and quantity in kilos produced per bed, average yield per bed, average weight in grams per head, per cent headed calculated yield per hectare in each treatment, value thereof, expenses per hectare and gain or loss for each fertilizer treatment*—Continued.

	E—Station fertilizer mixture No. 2			F—Station fertilizer mixture No. 3			G—Fertilica			H—Check (No fertilizer)		
	5E	25	21.61	6F	26	15.26	7G	27	19.24	8H	21	11.60
	13E	23	16.16	14F	17	12.00	15G	23	18.90	16H	26	8.56
	21E	23	14.80	22F	30	21.56	23G	32	29.64	24H	12	4.10
	29E	20	10.88	30F	19	12.00	31G	25	20.50	32H	2	0.34
		91	63.45		92	60.82		107	88.28		64	24.60
Average per bed	15.863+1.48			15.205+1.62			22.07+1.42			6.15+1.61		
Average weight per head in grams[1]	688			660			819			330		
Per cent headed and marketable	59.87			60.54			79.26			42.10		
Calculated yield per hectare in kilos	11,326.2			10,856.4			15,757.9			4,391.1		
Value at ₱0.10 per kilos	₱1,132.62			₱1,085.64			₱1,575.79			₱132.11		
Estimate expenses per hectare	774.12			₱791.71			₱329.90			₱347.69		
Gain or loss per hectare	₱358.60			₱293.93			₱745.89			₱208.58		

[1] Calculated per replication, instead of total results of variable.

It may be illuminating to compare the relative yield in percentage of the different fertilizer treatments to the unfertilized (check) beds, as follows:

A—Ammophos plus sulphate of potash	330
B—Ammophos	266
C—Leunaphos No. 2 plus sulphate of potash	298
D—Station fertilizer mixture No. 1	304
E—Station fertilizer mixture No. 2	258
F—Station fertilizer mixture No. 3	247
G—Fertilica	359
H—Check (No fertilizer)	100

SUMMARY

1. A fertilizer experiment on cabbage comparing seven commercial fertilizers was conducted in the regular season of 1936–37 at Baguio.

2. In the average yield per bed and the calculated yield per hectare, the fertilizer treatments stood in the following order: G—Fertilica, A—Ammophos plus sulphate of potash, D—Station mixture No. 1, C—Leunaphos No. 2 plus sulphate of potash, B—Ammophos, E—Station mixture No. 2, E—Station mixture No. 3, and check. The first four fertilizers named gave remarkable results.

3. In percentage of heading and marketable cabbage, the treatments were in the following order: A—Ammophos plus sulphate of potash, G—Fertilica, C—Leunaphos No. 2 plus sulphate of potash, D—Station mixture No. 1, B—Ammophos, F—Station mixture No. 3, E—Station mixture No. 2, and check.

4. There was variation in the average weight per head in the different fertilizer treatments, even if within the same variety. As a rule, the more favorable the fertilizer, the larger heads were produced.

5. In the most important fact sought, namely, the profit to be derived by the use of specific fertilizer, the different treatments come in the following order with the corresponding profit stated after each:

G—Fertilica	₱745.89
A—Ammophos plus sulphate of potash	580.21
D—Station fertilizer mixture No. 1	555.16
C—Leunaphos No. 2 plus sulphate of potash	433.60
E—Station fertilizer mixture No.	358.50
B—Ammophos	296.52
F—Station fertilizer mixture No. 3	293.93
H—Check (No fertilizer)	loss–208.58

6. A large loss is sustained by planting cabbage with our soil conditions without the application of some concentrated fertilizer, preferable complete. In spite of less expense of production, the check plot showed a loss of ₱208.36. On the other hand, with the most favorable fertilizer the yield can treble that of unfertilized cabbage.

V. COMPARISON OF THE BED AND BANKING METHODS OF CABBAGE CULTURE

The initial trial.—During the 1935–36 regular cabbage season, a commercial comparison of the bed and banking methods of culture was first tried at this station. Due to the facts that the different cultural plots were not intercalated, following the approved fashion for running replicated plots, using the *plant* only as a basis of comparison instead of the *mean yields of the plots*, and the use of another variety, the Early Market, this initial trial is not considered a part of the experiment of 1936–37, which will be described in detail in the following pages. However, a review of this first trial is interesting as it gave remarkable results, a precursor of the following experiment, and as the only reference on this new subject, justifying the need of conducting it on a regular experimental basis.

TABLE 5.—*Showing in parallel lines the 1935–36 comparative results of the bed and banking methods of cultures of the variety Early Market.*

Criteria	A—Bed culture	B—Banked culture	Difference in favor of A
Total number of plants studied	732	732	----------
Total number of plants headed	658	680	22
Per cent failed to head including unmarketable heads	10.11	7.10	3.01
Total weight of produce in kilos	742.0	833.2	91.2
Average weight of heads in grams	1,128	1,225	97
Calculated yield per hectare minus percentage not heading and unmarketable	25,146.5	28,222.7	3,076.2
Value at ₱0.08 per kilo	₱2,011.72	₱2,257.82	₱246.10
Estimate experiment per hectare on experiment basis	1,048.38	1,138.79	₱90.41
Profit per hectare	₱963.34	₱1,119.03	₱155.69

The results as shown by the above table convincingly show the superiority of the banked over the ordinary bed culture in practically all the criteria, with the only exception of the slightly larger expense of production.

Of paramount importance is the average weight per head, the basis of the tests, giving 1,225 grams in the banked method against 1,128 grams for the ordinary bed method or a difference of 97 grams in favor of the banked method.

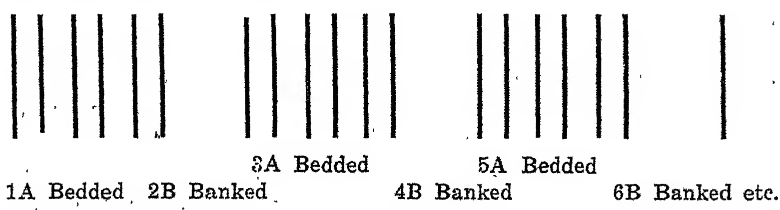
The net profit in the banked method of ₱1,119.03 was higher by ₱155.69 than the net profit of ₱963.34 from the bed method of culture. This difference of ₱155.69 in net profit makes the results of the banked culture very remarkable indeed!

The 1936–37 season experiment.—The present experiment comparing again these two methods was undertaken during the 1936–37 regular cabbage season.

Materials and methods.—Seeds of the newly imported variety, the Autumn King, were sown on November 12, 1936 and later pricked in open beds. The ground was converted into 10 equal sized plots with an area of 43 sq. m. each. Each plot could accommodate two beds, 1.1 m. by 15.3 m. with a 30 cm. path between them. The two variables with 5 replications each under comparison were:

A—Bedded plots
B—Banked plots

Since there was only one column of plots, they were laid in succession as follows:



The 5 A plots for the bed system were made into two beds each; on the other hand, the five B plots for the banked method were first planted flat.

Holes in triangles 50 cm. apart each way were due for setting the cabbage seedlings. In the plots for the banking method, the same layout and spacings as the bed method were maintained for setting the plants, in order to allow for the banking. Into each hole a shovelful of compost and 50 grams of the station fertilizer mixture No. 1 (10 N–15 P205–8 K20) were mixed thoroughly with the loose earth of each hole.

All the 10 plots were planted on December 26, 1936. Each plot contained 110 plants, or 550 plants for each variable.

On February 18, 1937, both variables A and B were dressed with ammonium sulphate, 5 grams per plant. Thirty days later another dressing of ammonium sulphate at the same rate was made.

Just after the first dressing, on the same day, the B plots were banked. Banking was the essential part of the B plots. When the plants were well established, about two months after transplanting, the part of the ground corresponding to the 30 cm. canals of the bedded plots was broken with the *tjankol* (Malayan hoe) and placed level on the banked bed, thus two banked beds were formed in each B plot. Part of the stem and the lowermost leaves of the cabbage, including the growth of weeds, mostly grasses, were buried *in situ* by the earth. When thus covered, the small weeds were buried and smothered. After the banking operation, the five A plots and five B plots, having two beds each plot, had the same appearance, with the notable exception that the newly banked beds showed neater and more level appearance with slight growth of weeds than the originally bedded plots. The cabbage plants in the B banked plots were lower with shorter exposed stems than the plants in the A bedded plots. Two banking operations at regular intervals should have been done, but since after the first operation produced the same height as the beds of the A bedded plots, only one banking was considered sufficient.

With the exception of banking, all the other essential field operations such as spraying, weeding, irrigating, and harvesting were similar and were carried out simultaneously in the two variables under comparison.

Results.—Harvests at regular intervals were made by priming the matured heads, beginning on March 23 and closed on June 7, 1937. The results were consolidated and are shown in the following table.

TABLE 6.—*Results of bed and banked cultures of cabbage, showing number of marketable heads, quantity produced per plot, average yield per plot in kilos, average weight in grams per head, per cent headed, calculated yield per hectare and value thereof at ₱0.10 per kilo, expenses per hectare and profit derived from each method of culture.*

	A—Bed Culture			B—Banked Culture		
	Plot No.	Headed	Yield	Plot No	Headed	Yield
	1A	86	83.78	2B	93	108.80
	3A	70	60.06	4B	75	82.38
	5A	82	101.08	6B	82	93.60
	7A	65	51.90	8B	60	64.58
	9A	45	24.56	10B	51	36.80
		348	321.38		361	386.16
Average yield per plot in kilos	65,276+9.03			77.32+7.08		
Average weight per head in grams [1]	858			1,041		
Per cent headed and marketable	63.3			65.5		
Calculated yield per hectare in kilos	15,180.5			17,981.4		
Value at ₱0.10 per kilo	₱1,518.05			₱1,798.14		
Estimated expenses per hectare	₱804.31			₱889.81		
Profit per hectare	₱713.74			₱908.33		

[1] Calculated per replication, instead of total results of each variable.

TABLE 7.—*Comparative results in parallel lines of the two methods of culture, showing the criteria and the differences in favor of the banked culture.*

Criteria	A—Bed culture	B—Banked culture	Difference in favor of B—Banked culture
Total weight of produce in kilos	321.38	386.16	64.78
Average production per plot in kilos	65.276	77.32	12.044
Average weight per head in grams	858	1,041	183
Per cent headed	63.3	65.5	2.2
Estimated yield per hectare in kilos	15,180.5	17,981.4	2,800.9
Value at ₱0.10 per kilo	₱1,518.05	₱1,798.14	₱280.09
Estimated expenses per hectare	₱804.31	₱889.81	—₱85.50
Profit per hectare	₱713.74	₱908.33	₱19.59

Interpretation of results.—In the comparative results of the two methods as consolidated and graphically shown in Table 7, the banked method of culture was found superior to the bed system of culture, except in the expenses of production. In the combined production of five replicated plots for each variable under comparison, the yield of the B–banked plots–was greater by 64.78 kilos than the yield of the A–bed plots. In the average

production per plot, likewise, the B plots produced 12.044 kilos more than the A plots. On the average taken per replication, the cabbage heads produced in the banked plots were heavier by 183 grams than in the bed plots. Again, there was a slight increase of 2.2 per cent of heads in the B plots over the A plots. When expressed in terms of hectare basis for comparison of possibilities, the banked culture yielded 2,800.9 kilos more of marketable cabbage than the bed culture. In comparing the gross income at ₱0.10 per kilo, the price at which this cabbage was sold, the banked culture produced ₱280.09 more than the bed culture. While in the total expense of production per hectare, the banked culture registered a higher expense of ₱85.50, due to the lack of skill of the laborers in the banking work, yet the net profit in the banked method of culture was ₱194.59 greater than the net profit derived from the bed culture. In the final analysis, this difference of profit is of the greatest importance, justifying the statement that the banked culture for cabbage is superior to the ordinary bed culture.

Summary.—1. Our initial commercial test in the 1935–36 regular cabbage season, comparing the two cultural methods, the banked culture was found superior to bed culture, which fact justified the carrying out of a real experimental study on the subject.

2. In this experiment during the 1936–37 season with five replicated plots, the banked culture was, again, found superior to the bed culture in the greater total production; higher average yield per plot; bigger heads of cabbage; greater percentage of plants heading; larger calculated yield per hectare; greater gross income; and most important of all, overshadowing all other advantages, was the greater net profit of ₱194.59 per hectare in favor of the banked culture.

3. This greater net profit justifies the general use of the banked culture of cabbage by gardeners to supplant the ordinary bed culture in vogue.

COMMERCIAL RAISING OF CABBAGE (*BRASSICA OLERACEA* L.)

(Farmers' Circular 5)

By ANIANO ELAYDA
Assistant Agronomist

TWO PLATES

Cabbage is one of the most important vegetables in the Philippines and in many respects, the most popular and universally used leafy vegetable. It is a very profitable crop when grown under favorable conditions. It is a crop that is easy to grow, but being comparatively a new crop in the Philippines, there are many points to be known as yet by our farmers.

P. I. PRODUCTION AND IMPORTATION OF CABBAGE

Year	Production			Importation	
	Hectarage planted	Yield (kg.)	Value (Pesos)	Quantity (kg.)	Value (Pesos)
1931	1,541	1,432,020	249,110	1,031,049	191,596
1932	1,469	1,186,270	169,530	888,198	146,441
1933	1,416	1,122,700	161,370	437,025	61,192
1934	1,449	1,147,320	154,900	629,033	101,402
1935	1,682	1,476,890	211,820	650,709	112,592
Average	1,511	1,273,040	189,346	727,183	122,645

Based upon the 1935 figures, our home production would have to be more or less doubled in order to do away with this importation.

VARIETIES

The most outstanding characteristics of the different varieties of cabbage tried under Philippine conditions are as follows:

1. *Early Flat Dutch.*—Early variety with solid, almost round, flat heads averaging 0.34 kilo per head in weight.

2. *Solid South.*—Late variety with big solid, nearly round heads averaging 0.58 kilo per head in weight. It is a good yielder and well adapted to places with a long dry season.

3. *Wood's Extra Early.*—Early variety producing nearly round, solid heads weighing 0.38 kilo per head.

4. *Late Flat Dutch.*—Late variety with big, solid, and almost round heads averaging 0.72 kilo per head in weight. It is one of the best yielders and adapted in warm climate.

5. *Sure Head.*—Late variety with big, solid, nearly round heads averaging 0.61 kilo per head in weight.

6. *Henderson's Early Summer.*—Early variety producing fairly big, nearly round, solid heads averaging 0.52 kilo per head.

7. *Copenhagen Market.*—Early variety, globe-shaped, compact and hard, weighing about 1.5 kilos per head under favorable conditions.

8. *All Seasons.*—Rather late variety, flat, large and hard, typically weighing about 2 kilos per head under favorable conditions.

9. *Early Jersey Wakefield.*—Early variety, compact, heavy conical head, rather small and typically averaging 0.63 kilo per head. It is a fair yielder.

10. *Early Winningstadt.*—Rather early variety, head conical and small to medium, typically weighing about 0.41–1.0 kilo per head. It is a good producer of heads.

In general, certain varieties or types of cabbages differ in size and yield of heads. It has been found that varieties with conical heads are better producers in number of heads than those with round heads, but they do not produce big heads and so are not as good yielders as those with round and flat heads.

The Horticulture Section of the Bureau of Plant Industry has made further studies of varietal test of cabbage under Philippine conditions and among over 30 varieties tested only the Henderson's Succession, Early Flat Dutch, Late Flat Dutch, Allhead Early, Charleston Wakefield, Solid South Sure Head, Henderson's Early Summer and Early Winningstadt have been found to grow well, possessing some special desirable qualities. These varieties, besides found well adapted to our local conditions are also very promising in the industry of growing this crop on a commercial scale.

SOIL AND CLIMATIC REQUIREMENTS

Successful cabbage growing requires a fertile soil with a uniform supply of moisture. This crop grows luxuriantly at high altitudes on account of the mild and favorable climate prevailing therein, but it can also be grown successfully at low altitudes

provided the soil is fertile with an abundant and uniform supply of moisture. It has been shown that this crop can be grown from low altitudes in the Central Luzon provinces up to an altitude of 8,000 feet as in the Mountain Province.

Cabbage is a short season crop, ranging from three to four months. Two to three crops a year could therefore be produced in succession on the same land. The most favorable planting period is during the cool months from October to January, but fairly successful crops could be raised at other periods of the year excepting July, August and September during which months the heaviest rains occur.

Commercial planting under intensive culture are found in Baguio, Benguet, where the climate is favorable. Very light soils usually deficient in organic matter are not suitable for cabbage growing because such soils have very poor moisture holding capacity and the crops suffer severely from lack of water and plant food.

PROPAGATION

For large scale planting of cabbage the propagation of seedlings is very important. Good seeds and vigorous seedlings are necessary requisites for getting a good crop. Every precaution should therefore be taken to avoid producing poor planting materials. Always secure seeds from reliable or reputable seed firms that sell seeds which are pure, free from admixture, uniform and genuine.

Preparation of seed beds.—Cabbage seedlings for large scale planting are raised in propagating beds. Ordinarily, these beds are made 1 to 1.2 meters wide each, and of any desired length, and raised 10 to 15 centimeters above the level of the path. During the periods of uncertain weather, that is, when heavy rains or extremely dry spells are expected to occur, a portable shed ought to be constructed over the bed to protect the tender seedlings from too much rain or excessive head, otherwise, a shed or an awning is not necessary.

The bed must be fairly or moderately rich, friable and mellow in order to have a moderate rate of growth of seedlings. A heavy soil is objectionable in that it is liable to harden and when the seedlings are removed for transplanting under destruction may affect the tender root systems. Likewise, open loose soil should be avoided as it dries up too fast. Extremely rich soil, on the other hand, would tend to produce weak, spin-

dling, soft seedlings unsuitable for transplanting under field conditions especially if the seedlings have not received adequate sunlight.

Sowing of seed.—Before sowing the seed, it is always advisable to take its percentage of germination so as to determine offhand the rate of sowing and the quantity of seed to sow for the desired area. The simplest way to test the percentage of germination is to place 100 seeds between 2 pieces of blotting paper on a glass or clay plate with a cover to fit, and then to keep the paper moist for one week or so. The percentage of germination can be taken by counting the number of seeds that germinated. Before the seed is sown, the beds should be sterilized by pouring boiling water or burning trash over them as a precaution against destructive soil fungi. After the beds have been put in condition, the seed should be broadcasted over the surface as uniformly as possible and then covered lightly with fine soil.

For every hectare, it would require 200 to 300 grams of seed with a germination of about 80 per cent. From 150 to 200 square meters of seed bed are sufficient to accommodate this quantity of seed. Of course, it is always desirable to sow a little extra amount of seed to give ample allowance for destruction by pests, diseases, etc., and for culling undesirable seedlings.

Care of seedlings.—The soil in the seed bed should be kept moist all the time. Weeds should be pulled off whenever they appear. If the seedlings are attacked by "damping off" diseases, all the infected ones including the few healthy seedlings immediately around the infected area should be removed together with the soil, and burned. Treating the infected area with 5 per cent formalin solution will minimize further infection. Crowded portions in the bed should be thinned out and pricked in the less crowded spaces so as to allow ample room for the seedlings to develop.

If the seedlings are grown under shed, the shed should be removed from time to time to harden the plants and about a week before transplanting, the seedlings should be completely exposed to the sun and watering withheld. After a month from the time of sowing, the seedlings ought to be ready for transplanting.

Preparation of land.—The land must be thoroughly plowed, harrowed and the weeds gathered and burned. Two or three

plowings and an equal number of harrowing would be enough to put the land into a state of fine tilth.

Field system of planting.—This system of planting may be appropriately termed the extensive system of growing cabbage in which the use of hand labor in cultivation and weeding is reduced to the minimum. The plants are set in single rows on shallow furrows during the dry season planting and in raised furrows or ridges during the rainy season planting. The ridges are made by plowing in such a way as to throw the earth from both sides toward the center. The newly formed ridges should be about 20 to 25 centimeters high a week or two before transplanting and at the time of transplanting when the earth shall have become firm and settled, about 10 to 15 centimeters. The seedlings should be set on top of the ridge in order to keep the plants above the water-logged soil especially if the soil is heavy and the water after the rains does not drain off readily. This system then would facilitate drainage which is essential during the rainy season planting. The furrows can be made to the desired depth by a proper adjustment of the plow.

The plot or bed system of planting.—This system of planting is resorted to in the intensive system of growing cabbage in which a large amount of hand labor is employed. The beds are made by the plow and afterwards put into proper finish by hand. The beds may be raised 10 to 15 centimeters above the level of the spaces or paths between them. The width of the beds should be large enough to allow double row planting. The plants are set 60 centimeters apart.

Transplanting.—Seedlings are ready for transplanting at the age of about a month. If the seedlings have been grown under shade and are tender, they should be exposed to sunshine to harden. Before pulling them up, the beds should be watered thoroughly to make the soil soft, thereby minimizing the breakage of the roots of the seedlings. Only healthy and vigorous seedlings should be planted. A trowel is a handy tool for making the holes in the furrows or ridges, as the case may be, in which to set the seedlings. In setting the seedlings care should be taken not to bend the roots as improper planting deters normal development. In non-irrigated land, the plants are to be firmly set and the soil lightly pressed against the roots. When irrigation by gravity is to be used, seedlings may be set in each hole with the use of a dibber and the roots covered with soil by hand. The soil is then irrigated by running water

along the furrows. A week later all dead or weak seedlings should be replaced.

Number of seedlings.—By the furrow system of planting in which the furrows are made 70 centimeters apart and the plants are set 60 centimeters apart in the furrows, there will be about 23,000 plants to the hectare. In the bed or double row system of planting, in which the plants are set 60 centimeters apart, there will be 27,500 plants to the hectare. The range of distancing would vary, depending upon the variety to be planted from 60 to 70 centimeters between plants and 70 centimeters to one meter between rows. The rate of transplanting per man-day would depend upon the skill of the planter and the preparation of the land. When the land is properly prepared, one planter can set around 6,000 seedlings a day.

CARE OF THE GROWING CROP

Cultivation.—A knowledge of the character of the root system of cabbage is essential in the proper cultivation of the crop. On well prepared land, cabbage roots penetrate to a depth of about 60 centimeters. Ordinarily, therefore, the root system, when fully developed, extends from the base of the plant which is only a few centimeters below the surface of the soil, to a depth of 60 centimeters. In the early stages of growth, cultivation may be made close to the plants to a depth of about 8 centimeters. But by the time the plants are half-grown, the roots entirely fill the spaces between the rows so that at this stage, cultivating at the same depth, especially if made close to the plants, will destroy many roots. A more shallow cultivation should therefore be made and mulching with a layer of rice straw, grass or leaves around the plants will be necessary. Deep cultivation will prevent root development in the rich surface of the soil.

Cultivation may be done by a toothed cultivator or by a garden hoe.

Manuring and fertilization.—Unless the land has been previously planted to green manure crops and contains sufficient organic matter, it should be dressed with liberal amounts of well rotted animal manure. The application of commercial fertilizers, such as ammonium sulphate and others will not prove very effective if the soil is deficient in organic matter. Before planting, the manure should be mixed thoroughly with the soil.

For economy in the use of fertilizing materials, each hill may be given a shovelful of manure and the commercial fertilizer applied as top dressing. If ammonium sulphate is used, one hectare would require from 350 to 500 kilograms.

The time and manner of applying commercial fertilizer is very important. A uniform and constant supply of quick-acting ones must be made available to the plants throughout their growing period to enable them to head early and produce a heavy crop. A deficiency in the supply of available plant food will retard the growth of the seedlings after transplanting, delay the heading of the plants and correspondingly reduce the yield. Experiences and good judgment are the best guides in determining the best time for applying the fertilizers. It must be considered that too early or too late application would not produce the desired result. After heavy rains, the quantity of readily available fertilizers in the soil is diminished and when not replenished, the plants may exhibit a yellowing of the leaves. Any application of more nitrogenous fertilizer is then necessary. It is believed that 2 to 3 weeks after transplanting the first application should be made and the second application 4 to 6 weeks afterwards. If the application of the fertilizer is made too early, much plant food may be wasted as the seedlings may not be able to use it up readily; if made too late or when the head-forming period is already passed, the application of fertilizers may not only fail to increase the yield but may also influence the production of soft heads.

Fertilizers for top dressing may be applied by hand and afterwards worked into the soil by cultivating it within the reach of the root feeding area.

Irrigation and watering.—Water is one of the principal factors in the success of raising cabbage. The soil should be kept moist but never soaked with water. The moist condition of the soil should be maintained during the active growing period from the time of transplanting.

In irrigating a cabbage field, two essential factors should be considered: (1) To keep the soil well supplied with water, and (2) To cultivate as soon, after irrigation, as the surface of the soil would permit, in order to conserve moisture and prevent cracking and backing. The frequency of applying water must be timed according to the condition of the weather, the water holding capacity of the soil, and the season of planting. When

there is no rain, watering may be needed once a day or in two days. Early planting will save labor in watering. Late planting in December and January may need frequent watering and more so as the dry season advances. After the heads begin to harden watering should be decreased.

Preferably, the water should be run in furrows alongside the plants or in paths between the beds and allowed to seep through the beds. To get an even distribution of water, the rows or furrows should not be made unduly long, especially in very porous soil.

Harvesting and handling.—Experience would guide one as to the proper time of harvesting the crop. The right stage at which to harvest would depend upon the marketing facilities of the variety planted. If intended for the early market and can be disposed of with dispatch, cabbage may be harvested as soon as the heads are big enough even if they have not yet attained the right firmness. If intended for distant shipment, the heads must be allowed to attain the proper firmness before being harvested otherwise, they are liable to get soft and spoiled or otherwise command a very low price. The pointed head varieties may be harvested as soon as the lower portion of the head gets firm; the top portion of the head is naturally less firm than the lower and do not get any harder even if harvesting is delayed. The round and flat varieties should be allowed to become hard when harvested and when the outer head leaves of a fully developed head curl upward and backward over the top of the head and have become distinctly lighter or more yellowish green. Mature cabbage should not be left long in the garden as the head is liable to burst. Bursting can be decreased by not watering the plant when already matured.

The heads should be severed from the plant with a sharp knife so as to include 2 to 4 wrapper leaves graded according to their sizes and then packed in well ventilated bamboo baskets. The heads should not be washed, otherwise rotting would take place.

PESTS AND DISEASES AND THEIR CONTROL

The cabbage crop is subject to the attack of many insects and fungus diseases, so much so that unless adequate and timely remedial measures could be provided, it becomes unprofitable to grow this crop. Since most gardeners and truckers are not familiar with the proper and effective control measures, they become reluctant to grow cabbage in spite of its being a remunerative crop.

There are two very destructive insects of cabbage, the cabbage caterpillar. *Crocidolonia binotalis* Zel. and the Diamond-black moth, *Plutella maculipennis* Curtis.

The cabbage caterpillar is one of the most injurious pests of cabbage. The caterpillars prefer to feed on the young succulent leaves and buds, mutilating or devouring them completely or boring into the heads and feeding inside.

The Diamond-black moth usually lays its eggs on the lower surface of the leaves and the larvae or caterpillars upon hatching feed on the leaves and riddle them with holes. The plants so damaged get stunted and in serious cases may produce no heads.

Spraying with soap solution.—A solution of one-fourth kilo of soft yellow laundry soap (Chinese soap) dissolved in 20 liters (one kerosene canful of water) has been found to kill the caterpillars or larvæ. The spraying should be done in the morning, or late in the afternoon and should be directed to the lower surface of the leaves where the caterpillars usually stay or hide. The spraying should be repeated three to six times whenever necessary.

Spraying with lead arsenate.—Spraying with lead arsenate at the rate of 1.5 to 4 grams per liter of water (30 to 80 grams or 6 to 16 level spoonfuls, for every petroleum canful or about 20 liters of water). Direct the spray especially to the lower surface of the leaves. To make the spray adhere better to the leaves, resin soap sticker at the rate of about 50 cubic centimeters per liter of the spray may be added.

If aphids or plant lice and white flies are present on cabbages, the following combined formula may be used:

Soft yellow soap	$\frac{1}{5}$ to $\frac{1}{2}$ kilo or 200 to 500 grams.
Lead or calcium arsenate........	30 to 80 grams or 6 to 16 spoonfuls, levelful.
Water	20 liters or about one petroleum canful.

The soap is not only deadly to the aphids and white flies but also to the caterpillars if the maximum amount of 500 grams is used. At the same time it serves as a sticker for the lead or calcium arsenate.

Collecting the eggs, larvae, and pupae and killing them will help reduce the damage.

Following are some of these diseases and their control:

1. *Club Root* (*Plamsodiophora brassicae. Wor.*)—Affected plants show a wilting of the foliage in the day, although re-

covering in the evening or during cloudy weather. Diseased plants are dwarfed, pale and sickly in appearance. The disease is more severe on seedlings whence it is carried to the field. The disease is caused by slimy mold.

The disease is controlled by liming the soil to minimize its effect by practising crop rotation, and by planting resistant varieties.

2. *Black rot* (*Pseudomonas campestris,* Pommel).—This disease is also known as stem rot. The symptoms are burned appearance of the margin of the leaves and yellowish of all the affected parts, except the veins, which remain blackened. The disease spreads from the leaves to the stems. It works in the fibro-vascular bundles of the leaves and main stalk, causing a premature defoliation. Plants seriously affected very often do not form heads.

To control the disease, the seeds before planting should be disinfected for 15 minutes in a solution of $\frac{1}{4}$ pint (0.473 liters) of pure (40 per cent) formaldehyde diluted in 7 gallons of water. Avoid the use of disease-infected manure in the seed bed and before sowing immerse the seeds in 1–1,000 solution of corrosive sublimate for 30 minutes rinse with clean water, and then dry. Practice crop rotation.

3. *Soft rot* (*Bacillus carotovorus, Jones*)—This disease causes trouble both in the field and in storage. The disease is characterized by soft, mushy to slimy decay of the entire plant. The disease works rapidly under favorable moisture and temperature conditions gaining entrance through a wound or bruise.

Proper ventilation of storage room, proper drying of cabbage by exposure to sunlight, and crop rotation in the disease fields are the methods of control.

4. *Damping off* (*Olpidium brassicae, Worr. Dang.*)—Seedlings are attacked in seed beds. Infected seedlings are soft and water-soaked at the base of the stem and when pulled break off easily.

Soil disinfection, proper shading and thin sowing of seeds in the beds will check or minimize the disease.

5. *Downy Mildew* (*Peronospora parasitica* (Pers.) *De By*)—This is a field disease causing considerable damage to young seedlings. It is characterized by whitish downy patches on the under side of the leaf. The infected areas are angular, pale yellow and somewhat shrunken.

To control the disease, the plants in the seed bed or in the field should be sprayed with 4-4-50 Bordeaux.

6. *Drop* (*Sclerotinia libertiana* Fckl.)—The trouble may be recognized by dropping and wilting of the leaves. On examining a dead plant, a white cottony fungus growth is found on the underside of the lower leaves, and near the moist regions at the stem end.

Plants which show indications of disease should be pulled out and burned and the place where it grew drenched with a solution of one pound of blue stone dissolved in seven gallons of water.

7. *Black leg or foot rot* (*Phoma oloracea* Sacc.)—The disease is usually manifested in the seed bed about two to three weeks before transplanting in the field. Infected seedlings usually collapse and take on a bluish color. In the field, the foliage of the older but affected plants usually take on a mottled, metallic, bluish-red color at the margins and the lower outer leaves wilt. On examining such plants there will always be found sunken lesions which often girdle the foot of the plant.

To control the disease, treat the seed bed with 4-4-50 Bordeaux, applied immediately after planting, at the rate of one gallon to each 10 square feet of bed space. The bed should again be sprayed with Bordeaux about two weeks before and once again at transplanting. Also treat the seeds as recommended under Black Rot disease.

8. *Black mold* [*Alternaria brassicae* (Berk.) Saac.]—This is a serious disease of cabbage. Affected leaves are covered with spots which are nearly black on the underside of the leaf. The spots are composed of a series of rings, the smaller ones enclosed within the larger. There is no distinct border separating the diseased from the healthy, the spots gradually shading off into the healthy tissue.

It may be checked by spraying with 4-4-50 Bordeaux mixture.

9. *Leaf spot* (*Cercospora bloxami* B. and Br.)—This is a disease of little importance.

10. *Wilt or yellows* (*Fusarium Conglutinan* Wall.)—This disease is so economically important that cabbage growers lose so heavily from wilt and in other cases has made cabbage growing very unprofitable.

Affected seedlings are yellowish and stunted in growth with a tendency to drop their lower leaves at the least touch. Such plants when planted in the field either die outright or make very slow growth. The symptoms in the older plants are the same as in the young plants. The outer leaves turn yellow

and drop off one by one until only the bare stump and top head are left. Under field conditions, high temperatures are very favorable for the spread and development of the disease.

Cabbage yellows can not be readily controlled. Naturally a clean seed bed should be chosen but even healthy seedlings when transplanted into infected fields will soon contract the disease. The same also holds true even when the seeds are disinfected. Neither is crop rotation a sure method of control. The best method of control is the development of resistant varieties.

11. *Root knot* [*Heterodera radicicola* (Greef.) Mull]—This disease is most prevalent in light soils. With proper culture and fertilization, however, a crop may be produced with practically very little loss. The disease is characterized by a swelling on the roots, showing itself in small knots formed either singly or in pairs, or in strings, giving the affected roots a beaded appearance.

ECONOMICS OF CABBAGE PRODUCTION

Estimate of cost of production by the field or double method of culture (not including land tax and interest on investment and depreciation) on a hectare of land.

Items of operation	Man days	Animal days	Approximate cost (pesos)
1. Cost of seeds, 200 grams	--------	--------	₱4.50
2. Cost of fertilizers, ammonium Sulphate at 500 kilos per hectare	--------	--------	40.00
3. Cost of seed bed preparation	3	½	2.90
4. Cost of raising seedlings which takes a month	8	--------	4.80
5. Cost of preparing land:			
(*a*) First plowing	3	3	3.30
(*b*) First harrowing	½	½	.55
(*c*) Second plowing	3	3	3.30
(*d*) Second harrowing	½	½	.55
(*e*) Third plowing, making beds	5	5	3.80
(*f*) Pulverizing soil and fixing beds	5	5	3.00
(*g*) Preparing and manuring the hills for planting	10	--------	6.00
6. Cost of stable manure or humus	--	--------	30.00
7. Cost of planting	38	--------	22.80
8. Cost of cultivation and weeding, 4 times	100	--------	60.75
9. Cost of spraying, 6 times	27	--------	16.20
10. Cost of dressing with fertilizers, 2 times	20	--------	12.00
11. Cost of watering by hand	280	--------	168.00
Cost of watering by gravity	8	--------	--------
12. Cost of harvesting	28	--------	20.80
13. Cost of crates and packing (20 centavos per crate)	--------	--------	100.00
14. Cost of insecticides	--------	--------	28.40
Total	--------	--------	531.15

Planting at a distance of 60 centimeters between plants in double rows, one hectare will accommodate around 27,500 plant hills and this number is reckoned to produce an estimated yield of 25,000 kilos. Based on the average yearly (1931–1935) importation, the value per kilo is approximately ₱0.19. Even estimating at ₱0.10 per kilo, the gross income per hectare reaches over ₱2,500, leaving a considerable margin of profit over the cost of production.

It has been found in Trinidad Valley, Benguet, that it costs ₱0.08 to produce a head of cabbage. In round number the cost of production per hectare fluctuates around ₱1,600 covering cost of fertilizers, control of pests and diseases and all other operations from the preparation of land to the marketing of the product. The production per hectare very rarely falls below the estimated production given above, so that net profit per hectare amounts to ₱900 or more. The raising of cabbage by truckers in the Trinidad Valley is done under very intensive methods of culture, but it is believed a substantial reduction of labor in cultivation and of the quantity of fertilizers applied, would not very materially affect the corresponding yield.

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ILLUSTRATIONS

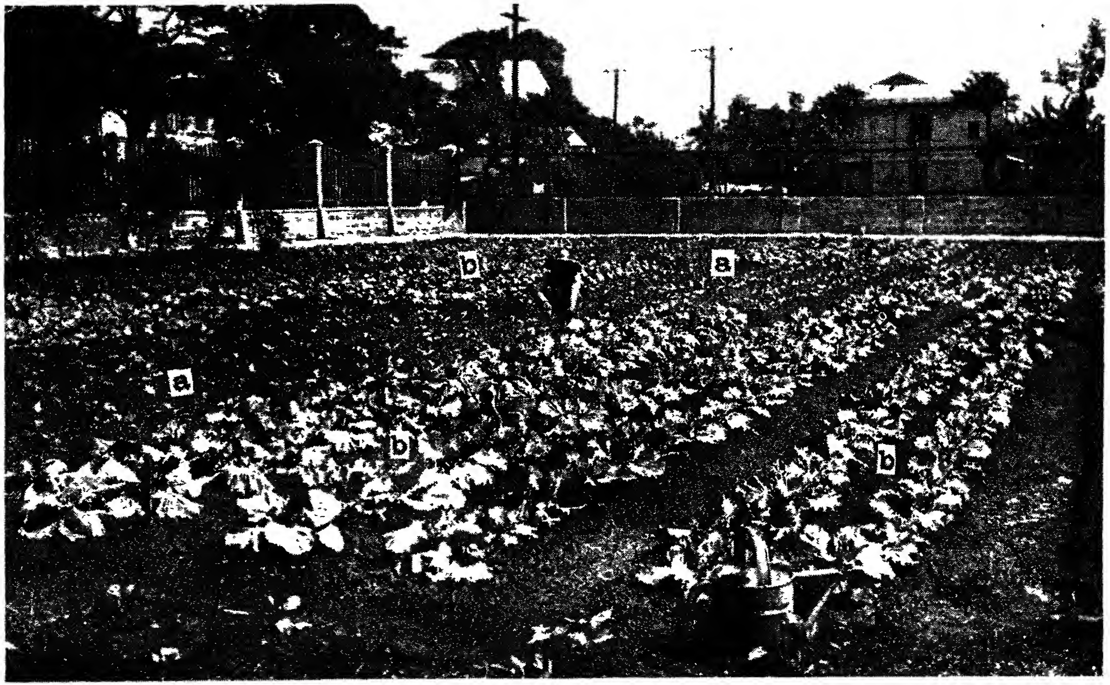

PLATE 1.

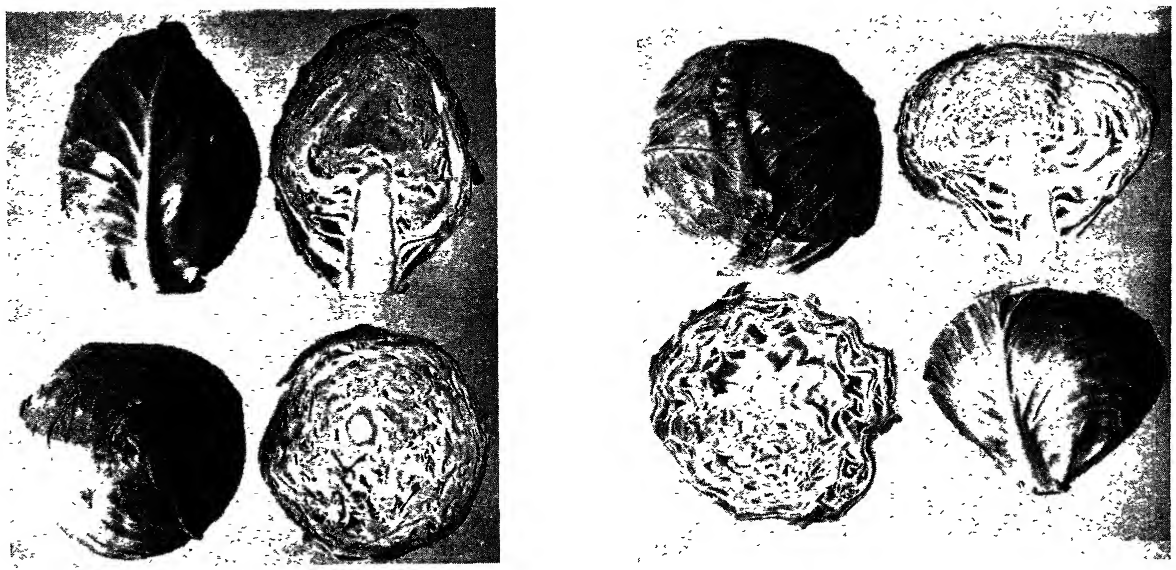

PLATE 2.

COTTON GROWING IN THE PHILIPPINES

(Farmers' Circular 10, Revised)

By ANIANO ELAYDA and FRANCISCO DE JESUS
Assistant Agronomists

FOUR PLATES

The development of the cotton industry in the Philippines is presently being encouraged by the Government in line with the program of crop diversification aimed at stabilizing Philippine agriculture. That cotton is well adapted to many regions in the Philippines is already beyond question. As a matter of fact, since the Spanish time and even before that, cotton has been cultivated in at least two sections of the country, namely, the Ilocano regions and Batangas. The Philippines is a great importer of cotton textile products amounting to over thirty million pesos annually. Japan needs at present big quantities of raw cotton materials to supply her highly developed and extensive textile manufacturing industries. The present local demand for raw cotton in the Philippines is for one local mill only so that the increase in local demand will depend upon the establishment of more manufacturing industries utilizing the raw material.

The fact that Japan is actually a great market and the Philippines a potential one makes it doubly sure that if cotton could be produced in the Philippines in great quantities and the cost of production is low enough to enable it to compete with cotton from other countries in the world's market, the Filipino farmers will find in cotton one of the important crops.

Philippine Islands importation of cotton and its manufactures

Year	Value
1931	₱32,802,095
1932	33,523,243
1933	26,263,250
1934	31,242,920
1935	30,599,841
1936	30,535,257

The values of our annual importation of "knitted cotton", thread and yarns during the years 1931, 1932, 1933, 1934, 1935, and 1936 are as follows:

Year	Knitted co'ton in the piece	Thread	Yarns
1931	₱308,381	₱1,984,900	₱1,177,255
1932	242,660	1,782,161	1,028,557
1933	328,236	1,514,718	866,658
1934	430,945	1,750,486	1,094,156
1935	315,367	1,817,482	1,015,173
1936	437,515	2,028,436	1,486,923

The above statistics plainly and conclusively show the importance of developing the cotton industry here.

VARIETIES

There are several species and numerous commercial cotton varieties in the world. In the Philippines, a number of commercial varieties of cotton has been tried; so far none of the newly introduced varieties has proved any better than the two naturalized varieties, the "Batangas White" and "Kapas Purao." These naturalized varieties may be described briefly as follows:

Batangas White.—Upright habit of growth; less resistant to heat and drought; age at blooming time, 84 days; percentage of ginning, 31 per cent; staple length, $1\frac{1}{16}$ to $1\frac{1}{8}$ inches; and yield of lint per hectare, 3.3 piculs.

"Kapas Purao."—The lateral primary branches have the tendency to lodge on the ground; age at blooming time, 78 days; percentage of ginning, 29 per cent; staple length, $1\frac{5}{6}$ to 1 inch; and yield of lint per hectare, 2.5 piculs.

SOIL AND CLIMATIC REQUIREMENTS

Soil.—While cotton is adapted to a wide range of soil types, too sandy and too heavy soils should be avoided. Light sandy to light clay loam are best types of soil for cotton. Soils suitable for the growing of corn, peanut and sugar cane are also good for cotton. A newly opened land gives usually a good crop.

Climate.—A tropical and moist climate is very essential for growing cotton successfully. During the sowing and seedling stage, light and frequent showers are beneficial. Excessive soil moisture is conducive to seed rotting and damping off of

seedings and later on, in the plant's development, it promotes excessive vegetative growth at the expense of boll production. A spell of dry weather which occurs at a later period causes the plant to be stunted, to mature early and, consequently, reduces the yield. Long drought causes it to wilt and hastens the shedding of the bolls and leaves.

An evenly distributed rainfall throughout the growing season alternating with several days of bright and warm weather is favorable to plant's growth. During the flowering period, the plant needs plenty of sunshine. As the crop matures and the bolls start to open, less moisture is necessary as wet weather retards crop development, interferes later with harvesting, and damages the lint in the open bolls. A sunny dry weather for the harvest season of at least three months is essential so that the picking of the bolls is easier, the crops produced are free from mold, and possess luster and white color.

The Weather Bureau classifies climate in the Philippines into four types as follows:

First type.—Two pronounced seasons: dry in winter (December, January and February) and spring (March, April and May); wet in summer (June, July, and August) and autumn (September, October, and November).

Second type.—No dry season; with a very pronounced maximum rainfall in winter (December, January, and February).

Third or intermediate A type.—No very pronounced maximum rain period; with a short dry season lasting only from one to three months.

Fourth or intermediate B type.—No very pronounced maximum period and no dry season.

Based on the climatic requirements of cotton, the regions falling under the second and fourth types of climate are generally not suitable for this crop. However, big quantities of cotton have been produced in Agusan, Bohol and Lanao. Agusan has produced alternately two crops of cotton due to the favorable climate existing in two distinct regions of the province.

Geographical distribution of cotton growing regions.—The adaptability of cotton in Batangas and the Ilocos provinces is already a known fact. The other provinces where cotton has been tried with success are the following:

Provinces having the first type of climate: Antique, Cavite, Iloilo, Mindoro, Occidental Negros and Pangasinan. Cotton has been found less suited in Central Luzon because of the

peculiar climatic conditions (hot and dry atmosphere), prevailing which were found unfavorable to the flowering and bolling stages of the plant.

Provinces having the third type of climate: Cagayan, Capiz, Cebu, Oriental Misamis, Occidental Misamis, Oriental Negros and Eastern Palawan.

Experience has shown that the success or failure of a cotton crop is conditioned upon the occurrence or non-occurrence of uncontrollable factors, namely, typhoons, drought, etc. The same factors also hold true with any other crops here or elsewhere.

CULTURE

Soil preparation.—The land for the planting of cotton should be prepared at the beginning of the dry season. The land is plowed and harrowed 2 to 3 times in the manner as preparing it for such crops as corn, peanut and tobacco.

Methods of planting.—There are two methods of planting, namely, (1) the ridge and (2) the furrow or "list." The ridge method is used when the planting is done quite early and there is the possibility that the water supply in the soil, especially if the drainage is poor, might go beyond the optimum needed and affect the seeds or young seedlings. The seeds should be sown on top of the ridge in order to keep the seeds above the water logged soil, especially if the soil is heavy and the water after the rains does not drain off readily. This system facilitates drainage which is essential during early planting.

The furrow or the "list" method of planting is used when the soil has the proper moisture content.

Time of planting.—Success in the growing of cotton in the Philippines depends largely upon the proper time of planting. Planting should not be too early or too late although it varies according to the locality. If cotton is planted too early as in August or the early part of September when the soil is still very moist, the tendency is for the seeds to rot or, if the seeds ever grow, the seedlings are weak and very susceptible to damping off. Hard rains accompanied by typhoons and floods often occur during these months which are very destructive to cotton planting.

On the other hand if cotton is planted as late as December the plants become stunted in growth due to insufficient soil moisture and high temperature that usually prevail during the months of January and February when the cotton plants

are still in the active growing stage. Planting as late as December is only advisable in some regions where the atmosphere is humid and there is adequate soil moisture as in Northern Mindanao and on the highlands of Batangas and Cavite. But the fundamental principle to be observed in all cases is to time the planting so as to bring the plants to maturity not later than the middle of the dry season.

The "Batangas White," being a late-maturing variety, should be planted from October to November and the "Kapas Purao," from November to December. The best time to plant the "Batangas White" is during the middle of October, and "Kapas Purao," during November.

Planting.—The distance at which cotton is planted varies according to the fertility of the soil. In soils of medium fertility the distance of planting should be closer than in rich soils. The furrows may be spaced 70 to 100 cm. and the hills in the furrows 50 to 80 cm. apart.

The quantity of cotton seeds to plant in a hectare depends upon the percentage of germination. On the basis of 80 per cent germination, 8 kilos of seeds would be enough for every hectare with sufficient allowance for destruction and for the removal of undesirable seedlings later. In Northern Mindanao where the plantings are made in wider spaces due to soil fertility and where the weather is very favorable to seed germination, 3 to 5 kilos of seeds are enough to plant in one hectare. Three to five seeds are planted to a hill in the same way as planting corn. The seeds germinate in 3 to 5 days from the time of planting. When the seedlings are about 20 centimeters high, the hills should be thinned by pulling off the weak seedlings, leaving only one or two healthy seedlings in each hill.

CULTIVATION

The field should be kept free from weeds. Since the crop is grown toward the dry season, the soil should be kept in good tilth to conserve the soil moisture as much as possible during the active growing period of the cotton plants. The first cultivation should be done about three weeks after planting or when the plants are about 20–25 cm. high. The second cultivation should be done about a month after the first, or when the plants are about to flower. Hoeing and weeding should be done from time to time, if necessary.

HARVESTING

From two to two and one-half months after planting, the cotton plants begin to bloom. Two months later, some of the bolls will mature and will be ready for picking. Picking should be done as soon as the bolls burst open. If picking is delayed after the bolls have opened for sometime, the floss is liable to be blown off by the wind or drop to the ground and get dirty. If picked early enough, the bolls may be immature and the floss obtained are likely to be of poor quality. For well opened bolls, the best way of picking is to remove the floss from the hard carpels.

The cool hours of the day in the early morning or late afternoon is the best time for picking. During the warmest part of the day the coverings or carpels of the bolls are brittle and are liable to be crushed and get mixed with the floss. As the bolls mature at different times, harvesting has to be done several times during the season, at intervals of from two to three weeks. After picking and removing the dirt from the floss, the cotton with seed is dried in the sun and then sorted before placing in sacks. The planters after harvesting their cotton crops usually sell their products with seed.

Some big planters or cotton growers' associations remove the seed before the product is marketed. This is being done by motor-driven ginning machines. The lint thus obtained is then baled at uniform standard weight (small bale-400 lbs.).

If the ginning is done immediately after the harvest, the seed for the next season's planting should be kept in air-tight containers to preserve their vitality and prevent them from getting moldy.

SELECTION OF PLANTS

The primary basis of selecting plants for the production of bolls for seed purposes is the high-yielding ability of the mother plant and its resistance to pests and diseases. The selection of high-yielding, disease-resistant plants should be made when the crop is nearing maturity.

CROP ROTATION

Cotton as a secondary crop to follow rice has been found under certain conditions to be very profitable. In Central Luzon, Zambales, Bataan, etc., where prolonged dry periods exist and where late maturing varieties of rice are planted, cotton does

not fit in as a rotation crop following rice. Based on extensive observations, cotton can be rotated with upland and early maturing lowland varieties of rice which are harvested not later than October. There is a systematic scheme of crop rotation which is beneficial not only to the cotton crop but also to rice. This is rotation with a leguminous cover crop as follows:

From May to the early part of October, the ground is planted to rice. In the second half of October, after the rice harvest, the land is prepared and planted to cotton. After the harvest of cotton, the land, if sufficiently moist, may be sown to any short-season leguminous crop and this plowed under as green manure when the land is prepared for the next rice crop. Should this arrangement be found unworkable under certain conditions, then the next best thing to do is to plant cotton only on one-half of the land after the rice harvest and the other half to legumes, and reversing the order in the following season by planting cotton where the legumes were planted during the last season and vice versa. Such a system will tend to conserve the fertility of the soil.

Sometimes corn is interplanted between cotton plants but this practice is not recommended, since the production of cotton is greatly affected by the intercrop. However, in Batangas this method is oftenly done for obvious reasons.

COTTON PESTS AND THEIR CONTROL

The cotton boll weevil (*Amorphoidea lata* Motsch).—One of the most injurious insect pests of cotton in the Philippines is the cotton boll weevil. As the name indicates, the insect is with a snout or beak at the end of which are the teeth and mandibles and other mouth parts. It is small, dark brown, and about 3 to 4 mm. long. The insects have been observed to gather in the newly opened cotton flowers in the morning, usually between 7 and 10 o'clock. The female punctures the young bolls and lays its eggs in the pistil and the resulting larvæ or grubs eat the young seeds and other soft parts of the seed capsules. The infested squares and bolls usually fall to the ground. As many as five larvæ have been found in a fallen boll. When full grown the larvæ leave the bolls and dig into the soil where they pupate.

Control.—(1) A prompt collection and burning of bolls that fall to the ground to kill the larvæ; (2) the beetles that congregate or gather in the newly opened flowers should be collected and killed; and (3) dusting the beetles in the newly

opened flowers in the morning with 50–50 mixture by volume of calcium arsenate and "gaogao." The bug *Geocoris tricolor* has been found to prey on the beetles and mealy bugs.

The cotton semi-looper or "abutilon moth" (*Cosmophila erosa* Hubn.).—This insect, a measuring caterpillar, has been found quite common on cotton as a leaf-feeder. It is capable of great injury to plants when present in abundance. Besides on cotton, the caterpillars have been observed to feed locally on the leaves of cowpeas. Okra is also one of its hosts. The caterpillars are about a millimeter long and are pale yellow when newly hatched. They soon become light green after feeding and the color becomes more pronounced as they grow older. A full grown caterpillar is about 4 cm. long and 3.5 mm. wide. The adult is brownish yellow, about 1.2 cm. long and with a wing expanse of about 3.8 cm.

Control.—(1) The caterpillars should be promptly dusted or sprayed with either lead or calcium arsenate, preferably the latter as it is cheaper. For dusting, calcium arsenate alone or diluted with "gaogao" may be used. In case of spraying, use from 1.5 to 4 grams of calcium arsenate per liter of water or 7 to 14 spoonfuls (levelful) for every petroleum canful (about 5 gallons) of water. Stir the mixture vigorously before spraying to keep the calcium arsenate particles in uniform suspension. A bucket pump, provided with rubber hose and with a good nozzle that will deliver the spray in fine mist should be employed. A soap solution containing a mixture of from 10 to 20 grams per liter of water ($\frac{1}{5}$ to $\frac{2}{5}$ kilos per one petroleum canful of water) has also been found an effective spray especially on the young caterpillars.

A hymenopterous parasite (*Euplectrus* sp.) has been found to attack the caterpillars. The egg parasite, *Trichogramma minutum* Riley, introduced here from the United States in 1934, has been found to attack the eggs of *Cosmophila erosa.*

The cotton pyralid leaf roller (*Sylepta drogata* Fabr.).—A rather common caterpillar which has been found on cotton is the pyralid moth, *Sylepta derogata.* This insect lays its eggs singly on the underside of the leaves similar to *Cosmophila erosa.* The caterpillar rolls the leaves wherein it feeds and pupates. This habit makes the pest more difficult to control than *Cosmophila.* Like *Cosmophila erosa* the first instar caterpillar feeds on the lower surface of the leaves, leaving the upper

membrane. The adults are yellowish white and measure from 2 to 2.3 cm. across the wings.

Control.—The control measures are the same way as suggested for *Cosmophila erosa.*

The pink bollworm (*Pectinophora Gossypiella* Saund.).—The color of this caterpillar is pink as the name suggests. It is one of the pests which is capable of serious damage when cotton is grown extensively. It has been reported quite destructive in La Union. In other countries, such as Brazil, Egypt and Mexico, it is known to be the worst pest of cotton. The caterpillar is about 1.2 cm. long and 2.5 mm. The adult is about 7 mm. long from the tip of the head to that of the abdomen. It is somewhat dark brown. The moths do not live long. According to records, the great majority of them die in confinement in from 14 to 20 days.

Control.—(1) Early matured bolls which are infested should be gathered and fumigated with either carbon bisulphide or sterilized with heat; (2) all the cotton seeds should be fumigated and stored in tightly closed containers; (3) after the harvest, old plants and fallen bolls should be destroyed.

Some of the other common but less destructive insect pests of cotton are as follows:

The common mealy bug (*Ferrisia virgata* Ckll.).—These insects are very prolific so that in a relatively short time they practically cover the cotton stems, especially so during the dry season. They also attack leaves. Among other hosts, besides cotton, are eggplant, tomato, mango, anona, casoy, cowpea, cabbage, pechay, patola, citrus, guava, etc. Colonies of this mealy bug are attended by several species of ants, among them is the common red ground ant, *Solenopsis geminata.* Spraying with soap solution with a concentration of 10 to 15 grams per liter of water or approximately $\frac{1}{10}$ to $\frac{2}{10}$ of a kilo for every petroleum canful of water is an effective control measure.

The melon aphid (*Aphis gossypii*).—These insects have been observed to attack cotton very early when the plants are about two weeks old. The colonies of the melon aphid present a motley appearance when these insects are crowded together on the underside of the leaves. Adult insects are about a millimeter long or even less. They are also abundant on eggplants, melons, upo, cucumber, pechay, etc. Lady beetles, aphis lion, and certain hymenopeterous parasite (family *Aphelinidae*),

have been found to prey on it. Colonies of this aphid are attended by the red and other ants. The melon aphids are controlled in the same way as the mealy bugs.

Leaf hoppers (*Empoasca flavescens* Fabr.).—One of the most common leaf hoppers on cotton is a small and green insect which is about 3 mm. in length. Like the melon aphids and the common mealy bugs, they become numerous towards the end of the rainy season and cause considerable damage to cotton crop. The female deposits her eggs in the midribs of the cotton plants causing the injured spots to swell. Both the adults and the young are voracious feeders causing the leaves to wrinkle. The other hosts are eggplants and potatoes. The control measure is the same way as that for mealy bugs and aphids.

The cotton stainers "Vacavacahan" (*Dysdercus sp.*).—The pest most common on cotton is *Dysdercus megalopygus*. The general color of the insect is red with black markings on the body. The adult rarely flies, but runs actively. Its long suctorial beak is able to enter the boll and suck out the seeds, causing the seeds to wither and the lint to be stained yellow. There is not much damage done to the plants and its injury to the bolls is not visible until the cotton is picked. The insects have many other host plants preferably the family *Malvaceae* to which cotton belongs. The control measure is to eliminate the alternative hosts, and brushing off the insects into a can of kerosene. Spray with soap solution (same strength as that used for mealy bugs) is also effective.

Other caterpillars.—Besides the larvæ of cotton stem weevil which have been observed to bore into the stems of cotton and causing swellings or gall-like formation thus making the plants stunted in growth, other lepidopterous larvæ such as the corn ear worm *Chloridea* (*Heliothis*) *obsoleta*, cotton leaf miner (*Lithocolletis triarcha* Meyrick) etc., attack the cotton plants by feeding on the leaves, cutting the young seedlings and attacking the bolls. Measures of control are to pick infested parts and burn them, collect and kill the larvæ, or dust with poisons and the employment of egg parasites.

COTTON DISEASES AND THEIR CONTROL

Angular leaf spot or bacterial blight (*Phytomonas malvaceara, Bacterium solanacearum* Erw. Smith).—This disease is caused by a bacterium which enters the plants through the stomata and

through injuries. The organisms attack the seedlings, leaves, bolls, stems and branches of the older plants. The spots on the leaves are watersoaked with yellow borders. The lesion on the stem is designated as black arm and produces a kind of gummosis. The infection on the bolls show circular spots turning brown and later, black. The organisms invade the developing seeds of the bolls and this is considered the most serious phase of the disease since many secondary organisms contribute to the damage. The known control measures are: (1) kill the bacterium on the seeds before planting by delinting the seeds with concentrated sulphuric acid and then treating them in hot water at 72° C. for 18 minutes; (2) infections in the field should be checked by removing the infected parts; (3) all introduced seeds should be grown in an isolated place for observation of diseases, and seeds for planting should be selected from disease-free plants.

Leaf blight (*Helminthosporium gossypii* Tucker).—The disease attacks the most conspicuous parts of the plants such as the leaves, bracts and bolls. The causal organism is a fungus. The disease might have been introduced into the Philippines with imported seeds. Early symptoms can be noted when the plants are 10 to 16 cm. tall. Spots of various sizes and shapes are observed on the leaves. These spots may be circular, zonated and sometimes irregular brown lesions on the margin of the leaves. They may attain considerable sizes especially when two or more of them coalesce forming bigger spots. The lower leaves show more of the disease. In the advance stage of the disease, the spots on the leaves may break off in a shot hole fashion.

The infections on the bolls at first appear as circular spots slightly sunken and dark brown, but later assume irregular shapes of various sizes. The badly diseased leaves fall on the ground and the badly infected plants are stunted in growth. The spread of the disease may be checked in the same manner as the bacterial blight.

Anthracnose (*Glomerella gossypii* Edg.) and (*Collectotrichum gossypii*).—The disease attacks seedlings causing damping off similar to damping off of other seedlings caused by other fungi. The seedlings may die or merely show lesions on the cotyledon. Lesions are also produced on the leaves and stems but serious manifestation of the disease is on the bolls. Brownish sunken

spots surrounded by reddish border are formed on the bolls resulting in the destruction of the bolls. The fungus spores live on the seeds for one year. The disease can be controlled by storing the seeds in dry places for one to two years, by seed disinfection, and by seed selection from disease-free plants.

Sclerotium disease of cotton (*Sclerotium rolfsii* Sacc.).—This disease is considered identical with *S. rolfsii* that attacks abacá, eggplants, lettuce, peanut, soybean and various other plants in the Philippines. It attacks the cotton plant usually on the stem at about the ground level or just below it. The bark in the affected region turns reddish brown, shrinks slightly and finally rots or decays. The rotting develops readily around the stem and then from the base to a few centimeters upwards. It is commonly observed that a cotton plant is completely girdled at the base of the stem. White fungus and sclerotial bodies develop on the surface of the host when there is a high humidity. In severe attacks the infection extends to the woody portion of the stem. The death of the plant at the base is later followed by the wilting of the leaves. Owing to the death of the cells and the gradual weakening of the tissues in the region of infection, the stem breaks and the whole upper portion of the plant topples over. The fungus attacks both seedlings and mature cotton plants; the seedlings are the ones most readily affected especially at the age of from 1 week to 10 weeks. Cotton plants a little over 4 months old seldom get the disease.

The sclerotial bodies of the fungus afford excellent materials for dissemination. The control measures are: (1) the *Sclerotion* disease in seed beds can be greatly minimized by soil sterilization—the soil infected with *Sclerotium* is heated to 100° C for 30 to 60 minutes to completely kill the disease; (2) remove all affected plant parts and burn them immediately; (3) spray with any fungicide like Bordeaux mixtures; (4) the practice of plowing and cultivating to bury the sclerotial bodies about 10 to 15 cm. deep in the soil stops the fungus sclerotia to germinate.

Other various diseases of cotton such as rust (*Kuehneola gossypii*) and Cercospora leaf spots (*Cercospora althaeiana* Sacc.) accompanied by *Alternaria* sp. have been reported but generally do not cause serious damage.

ECONOMICS OF COTTON PRODUCTION

Estimated cost of production of cotton per hectare (excluding land tax and interest on investment)

Field operation	Number of labor days		Appro-ximate value
	Man	Animal	
Cost of seeds (8 kilos at ₱.20 per kilo)			₱1.60
First plowing, ₱1.00 per day	7	7	7.00
First harrowing, ₱1.00 per day	2	2	2.00
Second plowing, ₱1.00 per day	5	5	5.00
Second harrowing, ₱1.00 per day	2	2	2.00
Furrowing, ₱1.00 per day	1	1	1.00
Planting, ₱.40 per day	[1] 5		2.00
First cultivation, ₱1.00 per day	2	2	2.00
Second cultivation, ₱1.00 per day	2	2	2.00
Hoeing and weeding, ₱.40 per day	[1] 5		2.00
First harvesting: picking, sorting, drying lint and sacking, ₱.40 per day	[1] 3		1.20
Second harvesting: picking, etc	[1] 3		1.20
Third harvesting: picking, etc	[1] 3		1.20
Fourth harvesting: picking, etc	[1] 2		0.80
Fifth harvesting: picking, etc	[1] 2		0.80
Sixth harvesting: picking, etc	[1] 2		0.80
Seventh harvesting: picking, etc	[1] 1		0.40
Cost of 10 big abaca sacks at ₱.26 per sack			2.60
Cost of transportation at ₱.20 per sack			2.00
Total expenses			₱37.60

[1] Number of days of woman labor.

Yield per hectare is about 600 kilos of cotton with seed, or 190 kilos of lint.

Price per kilo of cotton with seed	₱0.12
Cost of 600 kilos	72.00
Profit (₱72.00 minus ₱37.60 total expenses)	34.40

YIELD

Under favorable conditions, the normal yield of cotton in the Philippines in regions having a distinct wet and dry periods is from 400 to 500 kilos of cotton floss with seed. In Northern Mindanao where the climate has a dry season of at least three months and during which time the harvest of cotton bolls can be accomplished, very encouraging results have been obtained from the cotton crops. It has been reported that a hectare yields from 500 to 800 kilos of cotton with seed, although in some regions in Oriental Misamis, Agusan and Lanao, a yield of 1,000 kilos of cotton with seed is not uncommon.

MARKETING

The principal factor necessary to stimulate nation-wide interest in going into commercial scale planting of cotton is the presence of markets to absorb raw cotton locally produced. At present there is only one cotton mill working in the Islands with 900-ton capacity, owned by Madrigal & Co., Manila.

The present price of clean cotton floss with seed is ₱0.14 per kilo and that of clean cotton floss without seed is ₱0.45 per kilo, to be delivered at Manila. Better price will induce the planters to plant cotton on their available lands not otherwise planted to other main crops.

One of the Japanese firms, the Mitsui Bussan Kaisha, Ltd., offers ₱0.12 per kilo of clean cotton with seed in the regions where cotton has been raised, particularly in Northern Mindanao.

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ILLUSTRATIONS

PLATE 1.

PLATE 2.

PLATE 3.

1

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PLATE 4.

BOOK REVIEW

THE BIOLOGICAL CONTROL OF INSECTS

By HARVEY L. SWEETMAN

[461 pages, 142 figures, 1936. Published by the Comstock Publishing Co., Inc., Ithaca, New York. Price $3.75]

This is undoubtedly the most comprehensive and most useful book written so far on the biological control of insects. There are 14 chapters with a foreword of well deserved appraisal of the book and its author by Dr. L. O. Howard, former chief of the U. S. Bureau of Entomology, himself one of the leading authorities on biological control. The first chapter deals with the theoretical basis of biological control among the topics discussed being biotic potential and environmental resistance with special reference to parasites and predators. The whole of Chapter 2 is devoted to the use of resistant varieties of plants as a means of controlling insect pests. Suggestions are given by which the principles of host resistance may be utilized in plant breeding to produce insect resistant strains. In Chapters 3, 4 and 5 are described the role that bacteria and fungi, viruses and protozoa and parasitic invertebrate animals (nemathelminthes), respectively, play, and the extent to which these may be artificially utilized, in the biological control of insects. The greater portion of Chapters 6, 7 and 8, indeed of the entire book, are chiefly devoted to insect parasites and predators. Chapter 9 deals with some of the biological relations of insect predators and parasites to their hosts. Parasitism and predatism are compared and the different types of parasitism are discussed and illustrations of each type is given.

From a practical standpoint, Chapters 10 and 11 are most helpful. In Chapter 10 the factors which should be considered in the utilization of insect parasites and predators, such as multiple parasitism, hyperparasitism and polyembryony are discussed, together with the sequence theory of parasitism and the time factor in connection with the development and establishment of parasites and predators in a new region where they may be introduced. Chapter 11 deals with the points to

be considered before actual introduction may be attempted, the qualities desired in parasites and predators, methods of handling, shipping, rearing, liberation, etc.

Chapter 12 deals with the use of predatory vertebrate animals, such as toads, birds, mammals, etc. Chapter 13 presents the results of biological control and those that are considered still in the experimental stage are reported and the limitations of biological control are discussed. The biological control of pest plants (weeds) is the subject of the last chapter, Chapter 14, among the cases discussed being those with reference to troublesome cacti, especially in Australia, and Lantana in Hawaii.

The book is provided with a glossary and a long list of references which appears to include the most important works on biological control, and the index appears to be complete in every respect. It is apparent that the author has spared no effort to make the book really useful. It is truly authoritative and complete and constitutes a very handy and most valuable guide and reference to all interested in biology. To economic entomologists, in particular, who should be greatly benefited by it, the book is indispensable.—F. Q. OTANES.

ERRATA

PHILIPPINE JOURNAL OF AGRICULTURE

Volume 8, Number 4

Page 391, line 3—temperature; *read* temperate.
Page 445, line 8—2.5 to 0.3; *read* 0.25 to 0.3.
Page 445, line 8—6 to 60; read 16 to 60.
Page 457, reference 8—Butoc; *read* Butac.
Page 466, paragraph 4, line 1—derries; *read* derris.
Page 470, paragraph 2, line 2—Shoenobius; *read* Schoenobius.

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3. Halcon Rubber Station, Baco, Mindoro
4. Gingoog Lanzon Station, Gingoog, Oriental Misamis
5. Mandaue Seed Farm, Mandaue, Cebu

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The article in the Philippine Journal of Agriculture are indexed in the Agricultural Index, New York, N. Y.

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The journal is issued quarterly. The subscription price is 2 pesos (Philippine currency) or 1 dollar (United States currency) per year in the Philippine Islands and the United States and territories; 2 dollars (United States currency) in foreign countries. Single copies are sold at the same rates.

Subscriptions should be sent to the Chief, Publications Division, Department of Agriculture and Commerce, post-office box 613, Manila, P. I.

Publications sent in exchange for the Philippine Journal of Agriculture should be addressed: Scientific Library Division, Bureau of Science, Department of Agriculture and Commerce, post-office box 774, Manila, P. I.

Vol. 9 SECOND QUARTER, 1938 No. 2

The Philippine Journal of Agriculture

PUBLISHED QUARTERLY BY

THE DEPARTMENT OF AGRICULTURE AND COMMERCE

MANILA
BUREAU OF PRINTING
1938

16396

DEPARTMENT OF AGRICULTURE AND COMMERCE

Hon. EULOGIO RODRIGUEZ, A.B., *Secretary*
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THE PHILIPPINE JOURNAL OF AGRICULTURE

Published quarterly by the DEPARTMENT OF AGRICULTURE AND COMMERCE
Editorial Offices: DIVISION OF PUBLICATIONS, Oriente Building, Plaza Binondo, Manila

[Entered at the Post Office at Manila, Philippines, as second-class matter]

The Philippine Journal of Agriculture

VOL. 9 SECOND QUARTER, 1938 NO. 2

LIFE HISTORY AND HABITS OF THE COTTON BOLLWORMS IN THE PHILIPPINES WITH SUGGESTIONS FOR THEIR CONTROL [1]

By FILOMENO L. BUTAC

Of the Plant Pest and Disease Control Division
Bureau of Plant Industry, Manila

FOUR PLATES

Of all the insect pests of cotton, those that attack the squares and bolls are undoubtedly the most destructive. Of these, the one that has been studied to some extent by Woodworth (1922) and Otanes and Butac (1935) is the local cotton boll weevil, *Amorphoidea lata* Motsch. So far, however, very little is known in the Philippines about the caterpillars that attack the bolls, of which there are at least three species. Accordingly, it was deemed advisable to put together all local data available so far on these species.

Most of the data presented here deal mostly with the life history and habits of one of the species, namely, the spotted bollworm, *Earias fabia* Stoll., of the family Arctiidae. However, data on the life history and habits of another species, *Earias chromataria* Wlk., of the same family and those on the pink

[1] This study was conducted at Singalong, Manila, under Dr. Gonzalo Merino and Mr. Faustino Q. Otanes, Chief and Assistant Chief, respectively, of the Plant Pest and Disease Control Division. To them the author is very grateful for kindly reading and criticizing the manuscript.

bollworm *Pectinophora gossypiella* Saund., of the family *Gelechiidæ*, are also included.[2]

METHODS OF STUDY

Larvæ or caterpillars of *Earias fabia* collected from the field were confined individually in test tubes and each was supplied with food consisting of the top portions of healthy branches of cotton cut long enough to be accommodated conveniently in the test tubes. At times, young bolls were used instead of the shoots. These individual caterpillars were allowed to pupate. When the adults emerged, a male and a female were confined together in a breeding jar where the female was allowed to lay eggs on the fresh tip of a cotton branch provided for the purpose. Underneath the cheese cloth which covers the breeding jar, a ball of cotton, wet with dilute sugar solution for the adults to feed on, was suspended.

The eggs laid in a night were isolated by simply transferring the pair of adults or parents to another battery jar. When the eggs in each jar were hatched, some of the tiny caterpillars were confined individually in test tubes, each provided with tops of cotton for food, as in the case of the caterpillars collected from the field. The changes in the development of the insects were observed everyday.

LIFE HISTORY, HABITS, AND DESCRIPTIONS OF EARIAS FABIA STOLL

The eggs (Plate 1, fig. 10).—The eggs are small, almost round, about 0.4 millimeter in diameter, green, reticulated, with projections, or protuberances, at one pole. The incubation period ranged from 2 to 4 days with an average of 3.4 days under room temperatures, ranging from 23.3 to 30.6° C with a mean of 28.2° C, and relative humidities of from 56 to 76.7 per cent (Table 1)[3], with a mean of 67.6 per cent.

Larval stage (Plate 1, fig. 4).—The newly hatched larva is about 2 millimeters long, the head being darker in color than the rest of the body, which is light brown. The full-grown larva is about 16 millimeters long, of a purple color, and with

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[2] Most of the field observations in this work were carried on in the cotton cultures used for breeding purposes by the Plant Breeding Section, at Singalong, Manila.

[3] Temperature and relative humidity were computed from every two-hour reading each day. The hygrothermograph was placed in the laboratory near the breeding work.

TABLE 1.—*Life history of Earias fabia in the laboratory with the corresponding temperature and relative humidity for each stage from January 10, to May 15, 1935 and January 27 to May 1, 1936.*

Stages	Duration	Temperature	Relative humidity
Incubation period of eggs (71 cultures):	*Days*	°C.	*Per cent*
Maximum	4	30.6	76.7
Minimum	2	23.3	56.0
Average	3.4	28.2	67.6
Larval stage (30 cultures):			
Maximum	17	31.6	82.8
Minimum	11	21.2	54.5
Average	13.6	31.8	68.1
Pupal stage (35 cultures):			
Maximum	11	32.0	82.6
Minimum	8	25.6	54.4
Average	9	27.8	67.8
Emergence of adult to first oviposition (9 females):			
Maximum	5	30.7	79.4
Minimum	2	28.4	58.4
Average	3.4	29.3	69.1
Life cycle-egg to egg:			
Maximum	37	32.0	82.8
Minimum	23	21.2	54.4
Average	29.4	29.3	68.2
Longevity of adults (15 individuals of males and females together):			
Maximum	28	31.5	79.8
Minimum	3	21.2	54.5
Average	17.5	28.6	67.0

white spots on the back. Because of these white spots the caterpillar has been called "the spotted bollworm" in India. Both lateral sides and portions of the back near the head and near the caudal end are tinged with orange. The dorsal and lateral sides of the larva are provided with short strong hairs, or setæ; hence the caterpillar is sometimes called "spiny bollworm."

Table 1 shows the summary of data on the duration of the larval stage in the laboratory to be from 11 to 17 days, with an average of 13.6 days, under room temperatures ranging from 21.2 to 31.6° C, with a mean of 31.8° C, and relative humidities varying from 54.5 to 82.8 per cent, with a mean of 68.1 per cent.

The larvæ were observed to appear in the cotton fields before the plants were in bloom. At this stage of the growth of the plants, the larvæ bored into the stems and branches of the young plants from the buds, thus destroying the main

shoots and branches, which are potential producers of flowers or bolls (Plate 2, figs. 1 and 2). Between 9 o'clock in the morning and midday they were observed to wander from branch to branch in search of new ones to bore into. However, when flower buds, flowers, and bolls were already present, the caterpillars showed a decided preference for these; hence the name "bollworm."

The caterpillars hollow out the flower bud or otherwise eat all the contents. If it is an open flower that is attacked, they simply destroy the anther and then leave it in preference for the bolls. A very good indication of the presence of larvæ in bolls is the continuous discharge through the entrance hole of fresh excrement which may be seen projecting out from the side of an infested boll. The exit holes are located at the bases of the infested bolls (Plate 3, fig. 5). Once the larvæ are inside the bolls, they destroy one seed after another, and incidentally, damage the lint.

Pupal stage (Plate 1, fig. 7).—When the larva is ready to pupate, it comes out of the boll to spin a cocoon. It takes the larva about a day to complete the process. During this period it ceases to eat. The cocoon which encloses the pupa is boat-shaped, and the color varies from faint yellow to light brown. It is attached to either the petioles and branches of the plant or to the bracts of the bolls. The cocoon is small, measuring about 9 millimeters long and about 4 millimeters at its greatest width. The anterior end of the cocoon is loosely woven, which condition facilitates the emergence of the moth.

The pupal stage, under room temperatures ranging from 25.6 to 32° C, with a mean of 27.8°, C and relative humidities varying from 54.4 to 82.6 per cent, with a mean of 67.8 per cent, was found to be from 8 to 11 days, giving an average of 9 days (Table 1).

Adult stage (Plate 1, fig. 1).—The adult female is about 8 millimeters long from the tip of the head to the tip of the abdomen, and the wing expanse is about 20 millimeters. The antennæ are covered by the wings most of the time when the moth is in its natural resting position. The fore wing, pinkish yellow with a longitudinal triangular green streak in the middle, is fringed; hind wing, faint yellow and fringed; head greenish white, same with thorax except central part being greenish. The palpi, antennæ, legs, and abdomen are yellowish. The male adult is about the size of the female and is similar in appearance.

The insects are nocturnal. The females were observed to lay eggs only during the night, the eggs being laid singly on or near the terminal buds, and sometimes on bolls and flowers. In the laboratory at Singalong, Manila (Table 1), females were found to lay eggs in from 2 to 5 days (or with an average of 3.4 days) after emergence. The periods of fecundity (Table 2) varied from 8 to 22 days with an average of 13.3 days. The average number of eggs laid daily by a female (Table 2) ranged from 1 to 73 with an average of 19 eggs. The total number of eggs laid ranged from 91 to 327 eggs or with an average of 239 (Table 2).

Under room temperatures ranging from 21.2 to 32° C and relative humidities varying from 54.4 to 82.8 per cent, the life history of the insect in Manila, as shown in Table 1, from the time the eggs are laid to the time the adults begin to lay eggs, was from 23 to 37 days, the mean being 29.4 days. The corresponding mean laboratory temperature and relative humidity were 29.3° C and 68.2 per cent, respectively.

TABLE 2.—*Data on the reproduction of Earias fabia in the laboratory from January 10 to May 15, 1935 and January 20 to May 1, 1936.*

	Duration Days
Period of fecundity (4 females):	
Maximum	22
Minimum	8
Average	13.3
Number of eggs laid daily by a female (4 individuals):	
Maximum	73
Minimum	1
Average	19.4
Total number of eggs laid by a female during period of fecundity (4 individuals):	
Maximum	327
Minimum	91
Average	239.8

Under laboratory temperatures ranging from 21.2 to 31.5° C, with a mean of 28.6° C, the adults were found to live from 3 to 28 days in confinement or an average of 17.5 days. The corresponding relative humidities were from 54.5 to 79.8 per cent (Table 1), with a mean of 67 per cent.

LIFE HISTORY, HABITS, AND DESCRIPTIONS OF EARIAS CHROMATARIA WLK

Eggs.—The eggs are small, almost round, about 0.4 millimeter in diameter, green, reticulated, and with projections, or

protuberances, at one pole like those of the eggs of *E. fabia.* The incubation period is about 4 days under room temperatures of 28.3 to 30.5° C, with a mean of 29.2° C, and relative humidities of 59.4 to 69.6 per cent (Table 3), with a mean of 65.4 per cent.

TABLE 3.—*Life history of Earias chromataria in the laboratory with the corresponding temperature and relative humidity for each stage from January 15 to May 5, 1936.*

Stages	Duration	Temperature	Relative humidity
	Days	°*C.*	*Per cent*
Incubation period of eggs (16 cultures):			
Maximum	4	30.5	69.6
Minimum	4	28.3	59.4
Average	4.0	29.2	65.4
Larval stage (3 cultures):			
Maximum	21	31.5	76.3
Minimum	20	28.6	56.8
Average	20.7	30.0	65.1
Pupal stage (5 cultures):			
Maximum	12	31.5	87.8
Minimum	7	25.8	56.8
Average	10.0	28.2	70.5
Life cycle–Egg to emergence of adult:			
Maximum	37	31.5	87.8
Minimum	31	25.8	56.8
Average	34.7	29.1	67.0
Longevity of adults (3 individuals):			
Maximum	26	32.6	78.0
Minimum	15	26.9	64.6
Average	20.7	28.1	71.2

Larval stage (Plate 1, fig. 5).—The newly hatched larva is about 2 millimeters long, the head being darker than the rest of the body, which is light brown. The full-grown larva is light gray, about 16 millimeters long and the back is spotted with dull white. The dorsal and lateral sides of the larva are provided with short strong hairs, or setæ, like those of the larva of *E. fabia.*

Table 3 shows the summary of data on the duration of the larval stage in the laboratory under temperatures varying from 28.6 to 31.5°C, with a mean of 30°C, and relative humidities ranging from 56.8 to 76.3 per cent, with a mean of 65.1 per cent. Under these conditions, records on the duration of the larval stage were from 20 to 21 days, the average being 20.7 days.

The caterpillars bore into the stems and branches of the young cotton plants from the buds. After they have consumed the soft portions, they transfer to other shoots or branches. But like the caterpillars of *E. fabia,* they show a decided preference for the flower buds, flowers, and bolls.

The caterpillars hollow out the flower bud, or otherwise, eat all the contents. If they happen to attack an open flower, they

simply destroy the anther. When caterpillars are inside the bolls, they feed on the seeds, and in so doing they incidentally cut the lints. The presence of caterpillars in bolls can be detected by the fresh excrement projecting out from the side of the bolls near the entrance hole.

Pupal stage.—When the larva is ready to pupate, it comes out of the boll, begins to spin its cocoon, which lasts for a day. The cocoon is boat-shaped, like that of the cocoon of *E. fabia,* and is attached to either the petioles and branches of the plant or to the bracts. The color is light brown. The cocoon measures about 9 millimeters long and about 4 millimeters at its greatest width.

As shown in Table 3 the pupal stage is from 7 to 12 days, the mean, or average, being 10 days. The room temperatures and relative humidities under which these records were obtained were from 25.8 to 31.5°C, and from 56.8 to 87.8 per cent, the corresponding averages, being 28.2° C and 70.5 per cent, respectively.

Adult stage (Plate 1, fig. 2).—The adult female is about 7 millimeters long from the tip of the head to the tip of the abdomen. The wing expanse is about 17 millimeters. The fore wing is blue green with reddish-brown spots and is fringed with purplish brown. The base of the costa is reddish. The head is yellowish green and tinged with red; base of antennæ, reddish. The legs are tinged with red, although generally they are greenish white. The abdomen is also greenish white. The male is about the size of the female, and the color pattern is more or less the same.

The insects are nocturnal. The female was observed to lay eggs singly on or near the terminal buds and sometimes on the bolls and flowers of cotton.

The life of the insect under laboratory conditions in Manila, from the time the eggs were laid to the time when the adults began to emerge, under temperatures ranging from 25.8 to 31.5°C, with a mean of 29.1°C, and relative humidities varying from 56.8 to 87.8 per cent, with a mean of 67 per cent, was from 31 to 37 days, the mean being 34.7 days (Table 3).

The longevity of adults was from 15 to 26 days, with an average of 20.7 days, under room temperatures ranging from 26.9 to 32.6°C, and relative humidities varying from 64.6 to 78 per cent (Table 3). The corresponding averages were 28.1°C and 71.2 per cent respectively.

LIFE HISTORY, HABITS, AND DESCRIPTIONS OF THE PINK BOLLWORM (PECTINOPHORA GOSSYPIELLA SAUND.)

Eggs (Plate 1, fig. 8).—The eggs are small, elliptical, about 0.5 millimeter long and 0.3 millimeter wide, pearly white and are finely reticulated. About a day before hatching, the eggs turn faint orange with a distinct darker shade at one end, indicating the head of the developing embryo.

The incubation period ranged from 4 to 6 days, the mean being 4.7 days, under room temperatures ranging from 26.4 to 31.9°C, with a mean of 29.8°C, and relative humidities varying from 58.1 to 91.8 per cent, with a mean of 73.2 per cent (Table 4).

TABLE 4.—*Life history of Pectinophora gossypiella in the laboratory with the corresponding temperature and relative humidity for each stage from March 11 to June 28, 1935.*

Stages	Duration	Temperature	Relative humidity
	Days	°*C.*	*Per cent*
Incubation period of eggs (28 cultures):			
Maximum	6	31.9	91.8
Minimum	4	26.4	58.1
Average	4.7	29.8	73.2
Larval stage (13 cultures):			
Maximum	25	35.1	91.8
Minimum	14	26.4	54.4
Average	16.8	29.9	70.4
Pupal stage (19 cultures):			
Maximum	9	32.3	82.6
Minimum	5	27.8	54.4
Average	6.6	30.3	67.4
Emergence of adult to first oviposition (6 cultures):			
Maximum	7	31.9	82.6
Minimum	2	28.9	58.1
Average	2.8	30.6	71.6
Life cycle—egg to egg:			
Maximum	47	35.1	91.8
Minimum	25	26.4	54.4
Average	30.9	30.2	70.6
Longevity of adult (9 cultures):			
Maximum	25	32.3	91.8
Minimum	7	26.4	55.5
Average	14.8	30.4	73.8

Larval stage (Plate 1, fig. 6).—The newly hatched caterpillar is about 1 millimeter long, yellowish, and with a dark-brown head. As the larva grows, it becomes pink in color, hence the name, and the weak pale-yellow hairs, or setæ, scattered all over the body become more prominent. A full-grown larva measures, about 1.2 centimeters long and 2.5 millimeters wide.

Table 4 shows the summary of data on the duration of the larval stage. It ranged from 14 to 25 days, the average being 16.8 days. These records were obtained under room tempera-

tures ranging from 26.4 to 35.1°C, with a mean of 29.9°C, and relative humidities varying from 54.4 to 91.8 per cent, with a mean of 70.4 per cent.

The newly hatched larvæ were observed to feed temporarily on buds or flowers, transferring later to the bolls that offer abundant food for them (Plate 3, fig. 2). They remain in the bolls to pupate. Before pupation, they were observed to make exit holes for the adults. Infested bolls mature abnormally and the lint is short, colored, and kinky, and the seeds (Plate 4, fig. 2) are of poor quality.

It was also observed that some of the larvæ picked up with the crop during harvest enclosed themselves by fastening together two hollow seeds (Plate 4, fig. 1). These are the larvæ that will pass thru a period of aestivation, the longest period observed so far in the Entomology laboratory at Singalong, Manila, being about 5 months and 11 days. In Egypt, according to Hunter (1918) and Bedford (1923), the larvæ may continue to be inactive in cotton seeds for two years or longer. As was observed in Manila in 1935, larvæ in cotton bolls are not destroyed during the ginning process. Therefore, when the seeds for the next planting season are stored, the larvæ are stored with them, these emerging later when conditions are favorable. In this connection, the following observations by Richard (1924) are worthy of note:

> Most of the long-cycle larvæ pass through the ginning process uninjured, and remain dormant until, at the next sowing time, they are sown in the fields along with the sound seed. As soon as the humidity is sufficient they come out of their silk-lined chambers pupate within the tunnel and ultimately, in the course of a few days, emerge from it to await the opportunity afforded by buds and flowers for the all-important purpose of ensuring the continuance of their race, with the incidental cost to the cultivators of few crores of rupees.

While some of the larvæ of the later generation go to a state of aestivation, there are those that continue their life cycle by breeding on wild cotton and on the cotton plants left in the field. On several occasions during the off season for cotton in 1936 in the Central Experiment Station, Singalong, Manila, the author collected larvæ and pupæ of the insect from *Gossypium arborium* of the jayawant variety as well as from cotton plants left growing in the field during the time. So it could be readily seen that there are two sources of infestation

for each year's crop; namely, from adults that emerge from larvæ that aestivate, and from those that develop from volunteer plants and from those left in the field. Infestations may also come from perennial varieties of cotton plants.

Pupal stage (Plate 1, fig. 9).—Pupation takes place inside the boll as has already been pointed out. The pupa is orange to reddish brown in color, turning conspicuously darker about a day before the moth emerges. It is rather densely covered with short setæ, some of those at the anal end being distinctly longer and larger and are hooked at the ends. The length and diameter are about 9 and 3.8 millimeters, respectively.

The pupal stage (Table 4) under room temperatures varying from 27.8 to 32.3° C, with a mean of 30.3° C, and relative humidities ranging from 54.4 to 82.6 per cent, with a mean of 67.4 per cent, was from 5 to 9 days with an average of 6.6 days.

Adult stage (Plate 1, fig. 3).—The female moth is small and slender. It is about 7 millimeters long from the tip of the head to that of the abdomen and the wing expanse is about 15 millimeters. The color is gray to somewhat dark brown. The fore wings are rather sharp-pointed and are fringed along the apical margins. The hind wings are somewhat broader and are ending in even sharper point than the fore wings. They are fringed both along the apical and anal margins. The male moth is about the size of the female and is of the same appearance.

In the laboratory, the female was observed to lay eggs during the night. The eggs were found laid on various parts of the plant as on the bolls, squares, flower buds, and underneath the leaves when portions of the branches of the plant containing these parts were introduced in the breeding jar. Both sexes were inactive during the day, they being observed to hide most of the time between the particles of soil placed in the bottom of the breeding jar.

In the laboratory at Singalong, Manila (Table 4), females were found to lay eggs in 2 to 7 days (or with an average of 2.8 days) after emergence. The periods of fecundity (Table 5) varied from 6 to 10 days with an average of 8 days. The average number of eggs laid daily by a female (Table 5) ranged from 3 to 74 or an average of around 27 eggs, and the total number of eggs laid ranged from 194 to 234 eggs, with an average of 219 eggs (Table 5).

TABLE 5.—*Data on the reproduction of Pectinophora gossypiella in the laboratory from March 11 to June 28, 1935.*

	Duration
	Days
Period of fecundity (2 females):	
Maximum	10
Minimum	6
Average	8
Number of eggs laid daily by a female (2 individuals):	
Maximum	74
Minimum	3
Average	27.9
Total number of eggs laid by a female during period of fecundity (2 individuals):	
Maximum	234
Minimum	194
Average	219

The development of the insect from the time the eggs were laid to the time when the adults began to lay eggs, under laboratory temperatures ranging from 26.4 to 35.1° C, and relative humidities varying from 54.4 to 91.8 per cent ranged from 25 to 47 days, the mean being 30.9 days (Table 4). The corresponding mean laboratory temperature and relative humidity were 30.2° C and 70.6 per cent, respectively.

The longevity of adults was from 7 to 25 days, or an average of 14.8 days, under room temperatures ranging from 26.4 to 32.3° C, and relative humidities varying from 55.5 to 91.8 per cent (Table 4), the corresponding averages being 30.4° C and 73.8 per cent, respectively.

CONTROL-MEASURE SUGGESTIONS

The spotted bollworms.—In these studies on the life history and habits of the two spotted bollworms during the cotton seasons in 1935 and 1936, it was observed that infestations began during the latter part of December just before the beginning of the appearance of flower buds in January. From these observations, it would appear that cutting off the attacked shoots of cotton plants and picking and destroying all the early bolls showing signs of infestation will tend to minimize the infestation.

It is suggested that after harvest all cotton plants, including volunteer plants, be pulled out and burned, so that there is no food left for the insect in the cotton fields up to the next cotton season. As *Hibiscus esculentus* (okra) is an alternate host

of *E. fabia* as had been previously observed by Woodworth (1922) as well as on wild Malvaceous plants (Dammerman 1929), it would be advisable to destroy those that grow near or in cotton areas to prevent the insect from breeding before the cotton season. These two measures, otherwise known as clean-up measures, have proved a success in Egypt, where they have legislation demanding that all cotton plants, after harvest, be pulled out and burned together with the alternate hosts, *H. esculentus* and *H. cannabinus* (Gough 1919).

With regard to the use of insecticides, Deshpande and Nadkarny (1936) made extensive tests with lead arsenate, Paris green, calcium arsenate, and sodium silico-fluoride as means of control of *Earias fabia* and *E. insulana* They applied the first two insecticides to the cotton plants in the form of dust or spray (at the rate of 2 ounces of lead arsenate to 4 gallons of water and ½ ounce Paris green to 4 gallons of water), but found them ineffective in preventing damage by spotted bollworms. On the other hand, the same authors found out that calcium arsenate and sodium silico fluoride when used as dust have great possibilities of being useful in controlling the spotted bollworms provided that a very cheap and effective method can be devised in destroying the aphis infestation which develops after their use. Sodium silico-fluoride is more effective than calcium arsenate according to them. However, in the absence of the former, calcium arsenate may be employed for dusting, as in the United States against the Mexican boll weevil.

Pink bollworm.—Early matured bolls should be carefully examined, and those found attacked should be gathered and fumigated with carbon bisulphide or with a mixture of ethylene dichloride and carbon tetrachloride.

It is also suggested that after harvest, old plants and fallen bolls be destroyed by burning them. Volunteer plants during off season and alternate host, like the *Gossypium arborium* of the jayawant variety and other perennial varieties of cotton, especially those that are found near cotton fields, should be destroyed to prevent the insect from breeding there prior to the regular crop.

As most of the aestivating larvæ are found in the fastened seeds, it is suggested that all seeds for planting be fumigated or dried well before storing them in tightly closed containers.

TESTS WITH DERRIS ON EARIAS FABIA

On March 2, 1936, 5 caterpillars of *Earias fabia* were dusted in the laboratory with a fifty-fifty mixture (by weight) of derris dust and "gawgaw." The derris dust had a rotenone content of about 3 per cent. An hour after dusting, the caterpillars were observed paralyzed and all died within a day.

On March 24, 1936, the test was repeated on 10 caterpillars. It was observed too that the larvæ were paralyzed an hour after dusting, and on the second day all were dead.

In connection with these tests, it may be of interest to include the following observations made in relation to the dusting that was made with derris-gawgaw on cotton plants in one of the plots at the Philippine Carnival Exposition in 1936. The main purpose of dusting was to control the leaf-eating caterpillars, especially those of *Cosmophila erosa,* which were found abundant on the plants. The dusting was performed at about 9 o'clock in the morning. In the afternoon between 2 to 3 o'clock the plants were examined and collection was made of the insects found, especially those affected with the treatment. The insects collected were the following: 96 caterpillars of *Cosmophila erosa,* all paralyzed and 61 of them died after 2 days; 5 caterpillars of *Earias fabia,* all paralyzed and all died after 2 days; 19 adults of the local cotton boll weevil, *Amorphoidea lata,* all dead and were collected from inside the corolla of the flowers; 4 adults of cotton stainer, *Dysdercus megalopygus,* all dead; 9 lady bird beetles (predators), all dead; 4 hymenopterous insects, all dead and were collected from inside the corolla of the flowers; 16 larvæ of *Prodenia litura,* all vigorous and none died.

The results of the tests in the laboratory and in the open with derris-gawgaw indicate that the mixture has a promising value in the control, not only of the larvæ of *E. fabia,* but also of other insect enemies of cotton, and that further tests are necessary with the object of finding out, among other things, the rate and cost of application per hectare.

NATURAL ENEMIES

The pupa of *E. fabia* and that of the pink bollworm were found attacked by a hymenopterous parasite belonging to the Genus *Brachymeria.* The introduced egg parasite, *Trichogramma minutum,* was observed to parasitize readily the eggs of the

two spotted bollworms in test tubes. Tests conducted showed that 30 females of *T. minutum* could parasitize about 500 eggs of *Earias fabia.* The efficacy of using *T. minutum,* however, in the field remains yet to be studied.

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ILLUSTRATIONS

[The colored plate was prepared by one of the Bureau's former artists, Mr. Jose Olivares, and the photographs were taken by the Division of Publications, Department of Agriculture and Commerce.]

PLATE 1

FIG. 1. Adult of *Earias fabia*.
2. Adult of *Earias chromataria*.
3. Adult of *Pectinophora gossypiella*.
4. Larva of *E. fabia*, dorsal and side views.
5. Larva of *E. chromataria*, dorsal and side views.
6. Larva of *P. gossypiella*, dorsal and side views.
7. Cocoons of *E. fabia*, note the variation in color.
8. Eggs of *P. gossypiella*.
9. Pupa of *P. gossypiella*.
10. Egg of *E. fabia*, side and top views.

PLATE 2

FIG. 1. Portions of cotton shoots cut before the blooming stage, showing the injury by the larvae of *E. fabia*. A caterpillar is shown by an arrow.
2. Cotton plants with their shoots damaged by the larvae of *E. fabia*.

PLATE 3

FIG. 1. Cotton bolls and flower bud showing the larvae and the exit holes for the adults of *E. fabia*.
2. Cotton bolls attacked by the pink bollworm. Note how the lints are affected.

PLATE 4

FIG. 1. Fastened seeds of cotton containing aestivating larvae. These seeds passed through the cotton gin with the larvae in them uncrushed. Lower shows the same seeds opened.
2. Normally matured cotton bolls and abnormally matured ones due to the attack of the pink bollworm.

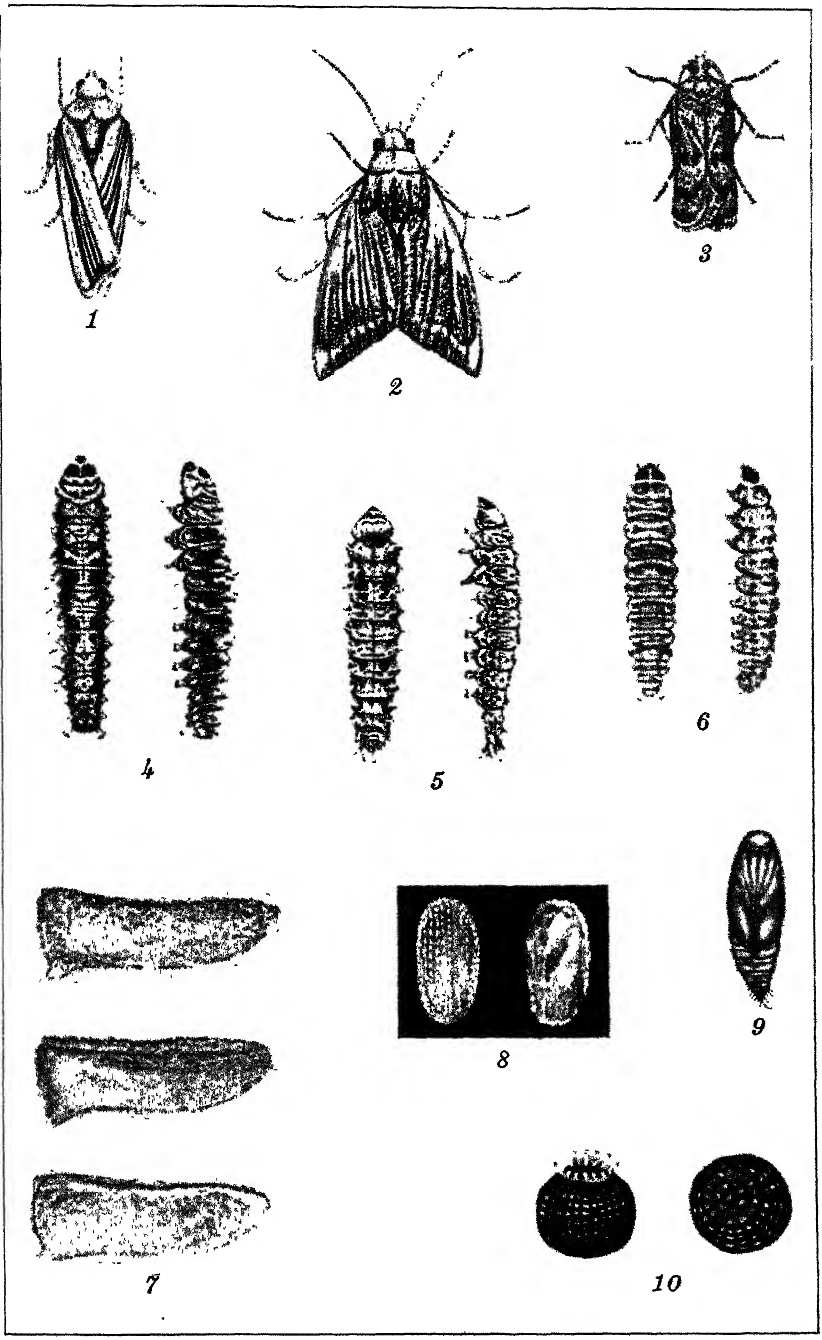

PLATE 1

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PLATE 2

1

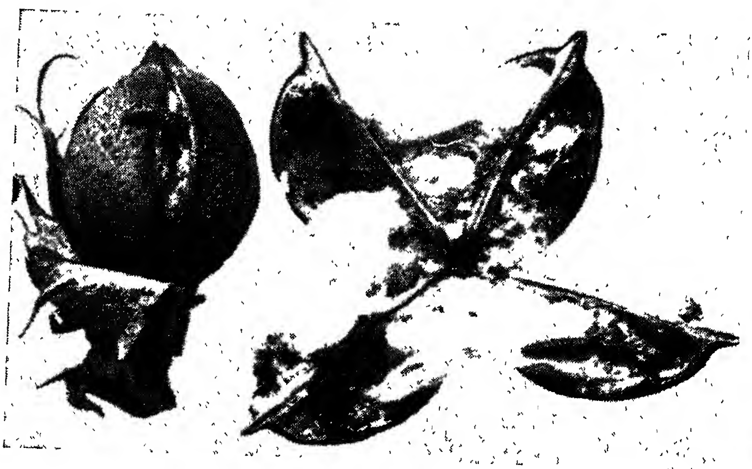

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PLATE 3

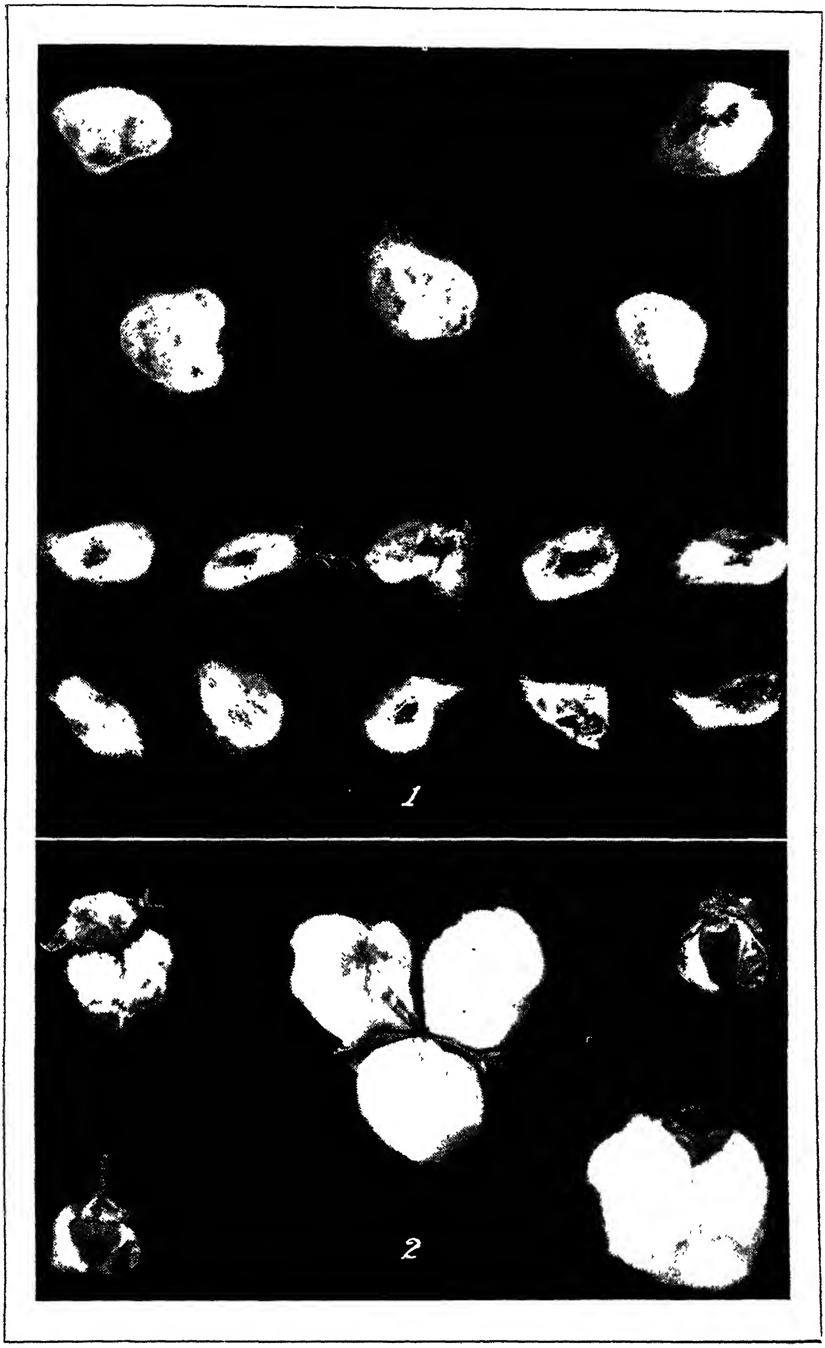

PLATE 4

VASCULAR DISEASE OF ABACÁ (MANILA HEMP) IN DAVAO

PROGRESS REPORT NO. 1

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ELEVEN PLATES

A serious disease of abacá, or Manila hemp, (*Musa textilis* Née) with symptoms similar to banana wilt, or Panama disease, was observed in Davao. (Plates 1 to 8 and 11.) It first attracted public attention in the early part of 1937. Prior to November 11, 1936, Messrs. Bonifacio Padilla, Acting Provincial Agronomist of Davao, and Pastor R. Villanueva, Plant Sanitation Foreman, sent diseased abacá specimens to the Central Office, Bureau of Plant Industry, Manila, for identification and investigation. They reported that the abacá plants were entirely killed by the prevailing disease and that the extent of damage was very alarming. The specimens were collected from Mindanao Reclamation Company, Tongkalan, Guianga District. Studies have been conducted in the Plant Pathology Laboratory since then. From these specimens, a fungus and bacteria were isolated on November 21, 1936. At that time, however, the bacteria isolated were not given particular attention, because the specimen under study was already in a state of decomposition. Further ocular examination showed the presence of tunnel and a larva of a stem weevil.

On February 17, 1937, the writer made an investigation in Davao in compliance with the request made by Mayor Santiago Artiaga of the City of Davao, to the Director of Plant Industry on January 27, 1937. The first official report on this investigation was submitted to the Director on April 1, 1937.

In this investigation, it was revealed that the first occurrence of this particular abacá disease dated back as early as 1931–1932. It was first observed in the Upper Bayabas, Guianga District, 3,000 to 3,600 feet above sea level. At that time there was not much cause for alarm, because the foci of in-

fection were located only in localized sections of the plantations. In 1934, the disease was discovered in Mindanao Reclamation Company, Tongkalan, 1,600 to 1,750 feet in altitude. The same disease also appeared in Gumati in 1935. In December, 1936, it was noted in Serib and Manambulan. On June 16, 1937, the same disease was found in less than a hectare of abacá plantation in Lipadas, about 5 feet above sea level and 12 kilometers away from the nearest infected place. The writer's attempt to trace the possible introduction of the vascular disease from the higher altitude to the lower altitude failed. While it is true that the vascular disease of abacá was previously reported as prevalent only in higher altitude and has wrought considerable damage to the crop, it is equally true that at present the same trouble is also playing havoc on the plantations at lower elevations. The other places infected with the vascular disease of abacá are Daliaon Plantation, Barakayo Plantation, Eden Plantation, Catigan, Cabantian, and Malita. The total infected area surveyed up to July 31, 1937 was placed at 309.43 hectares, and the area freed from the disease was 54.11 hectares. The aggregate value of the damage was roughly estimated at between ₱200,000 and ₱300,000.

On February 3, 1937, the same disease was the subject of a report by Mayor Artiaga of Davao to the Director of Plant Industry. During the same month, Mr. H. T. Edwards, Fiber Expert of the U. S. Department of Agriculture and J. H. Permar of the United Fruit Co., brought the seriousness of this disease to the attention of the Honorable, the Secretary of Agriculture and Commerce, the Director of Plant Industry, and the officials of the Bureau of Plant Industry particularly concerned. The same disease was the subject of an appeal by the Davao Chamber of Commerce to the Director of Plant Industry. Before these reports and appeals were received, the investigations and eradication campaigns were already in progress. Since then, the situation became very much improved and all of the seriously infected plantations were gradually freed from the disease. More recently this work gained considerable momentum, because of the allotment of ₱6,000 with which to finance the eradication work.

On March 28, 1937, diseased abacá specimens from the higher altitudes of Gumati, Tongkalan, and Upper Bayabas were brought by the writer to the laboratory and were used in the studies now in progress. Species of *Fusarium* and bacteria

were again isolated on April 2, 1937. The bacteria were again discarded for the same reasons as previously mentioned. Diagnosis of the diseased plants showed symptoms resembling very closely those of banana wilt, or Panama disease (Plates 1 to 5). The vascular strands are similarly discolored (Plates 6, 7). On account of the infections of the vascular tissues, the disease is referred to as a vascular disease. On bananas, however, the color of the diseased vascular bundle is crimson purple, while on abacá, violet red. It was also noted that in many cases, tunnels produced by a weevil, *Odoiporus paganus* Uichanco, were found in the diseased plants (Plate 6). What relation this insect has to the disease is not as yet known.

On May 1, 1937, another field investigation was made. At the same time, eradication campaign on a large scale was organized. In this campaign the roguing method followed in the eradication of the bunchy-top disease of abacá was adopted (Plates 9, 10). This method consists of digging out all infected plants and destroying them completely by fire or by other means of eliminating sources of infection. Other diseases like bunchy-top and mosaic are also included in the eradication work.

In July, 1937, Ocfemia(6) reported that "the so-called 'new disease' of abacá in Davao is not a single trouble. It seems to be the combined effect of banana-wilt-like disease and the stem weevil on abacá forced to grow at high altitudes."

According to Lee and Serrano(1), Teodoro(2) and Teodoro and Serrano(3), the heart rot of abacá in the Philippines is caused by a fungus similar to, if not identical with, *Fusarium cubense* E. F. Smith. Ocfemia(4) reported that this fungus does not cause heart rot but it caused vascular infection. In a similar subsequent investigation, Leoncio(5) claimed that the fungus is capable of infecting abacá seedlings only through injuries of the corms and pseudostem. However, both Ocfemia and Leoncio concluded that the infected plants outgrow infection, and the plants recover from the disease. From the new abacá disease in question, however, no cases of recovery have been observed. Since the disease appears to be different from any of those previously reported on the abacá plant, the information here given may be of great value in further investigation of the disease, and for its ultimate control.

INVESTIGATION ON THE CAUSE OF THE DISEASE

Examination of 306 abacá plants showed that 109, or 35.62 per cent, manifested both the disease and the weevils or tunnels

produced by the weevils; 173, or 56.63 per cent, with vascular infection or the disease alone, no weevils or weevil's tunnel; and 24, or 7.84 per cent with weevils and tunnels but no sign of vascular infection.

From fresh and slightly infected abacá specimens collected at different plantations, isolation studies were again attempted. Bacteria of pure culture were oftentimes isolated from the corm, pseudostem, and even from the very tip of the discolored tissues of the petioles of the leaves. Records of this study also show that in many cases only pure culture of *Fusarium* was isolated from the corm or base of the plant, pseudostem, but not at the very tip of the discolored tissues of the particular diseased specimen. This finding made the writer suspicious. Cross sections of the discolored vascular tissues of the petioles and leaves were examined under the microscope and showed myriads of motile bacteria inside the xylem vessels, parenchymatous cells, and phloem.

In the present investigation which has been going on since November, 1936, the result shows that the disease is associated with bacteria and a fungus which is very similar to *Fusarium oxysporum* Schlt. f. 3 Wr. (*Fusarium cubense* E. F. Smith). A weevil, *Odoiporus paganus* Uichanco, is also found associated with the diseased plants. The predominance of the presence of bacteria on the diseased tissues over that of the fungus is very marked. The bacteria, the *Fusarium*, and the weevil are at present being used in the inoculation studies.

More extensive studies to complete this investigation are at present in progress in the Plant Pathology Laboratory, in Davao and in Silang Abacá Disease Experiment Station.

ACKNOWLEDGMENT

The writer wishes to take this opportunity to acknowledge the splendid coöperation of the Mayor of the City of Davao, of the Provincial officials of Davao Province, of the Davao Chamber of Commerce, of Mr. Kojima of the Ohta Development Co. and Mr. Kobayashi of the Davao Japanese Association and of the Director of the Oriental Hospital, for laboratory facilities, without which the solution of these important problems of the abacá industry would not be possible.

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ILLUSTRATIONS

PLATE 1

Abacá plants (Maguindanao variety) attacked by the vascular disease. (Note the wilting of the leaves and breaking down at the base of the petioles.)

The specimen was collected from Mindanao Reclamation Co., Tongkalan, 1,750 ft. above sea level. Photographed February 25, 1937.

PLATE 2

A close-up view of the specimen shown in Plate 1. Note (*a*) The rotting or blackening at the base of the pseudostem, (*b*) The flapping down of the dried infected leaf sheaths around the base of a diseased abacá plant. Compare this picture with Plate 3. The specimens were obtained from Mindanao Reclamation Co., Tongkalan, 1,750 feet above sea level. Photographed February 27, 1937.

PLATE 3

Latundan variety of banana attacked by the banana wilt, or the so-called Panama disease. Note the blackening or rotting at the base of the plant and compare it with the symptoms produced on the abacá plants, Plate 2. This specimen was collected from Upper Bayabas Plantation, Guianga District, 3,000 feet above sea level. Photographed March 17, 1937.

PLATE 4

A diseased pseudostem of an abacá plant, cut slantingly to show the discoloration of the fibrovascular bundles and around the pitch, or heart, of the plant. The natural specimen was collected from Mindanao Reclamation Co., Tongkalan, 1,750 feet above sea level. Compare this with Plate 5. Photographed February 27, 1937.

PLATE 5

A portion of the pseudostem of a wilt-infected banana plant (Latundan variety), cut slantingly to show the discoloration of the fibrovascular bundles around the pith. Compare it with a diseased abacá plant on Plate 4. This specimen was collected from Upper Bayabas Plantation, 3,000 feet above sea level. Photographed March 17, 1937.

PLATE 6

A longitudinal section of an abacá plant infected with the vascular disease. Note the discolored area on the corm. Note also the tunnel made by the larva of the weevil. The specimen was collected from Mindanao Reclamation Co., Tongkalan, Davao, 1,750 feet above sea level. Compare this with Plate 7. Photographed February 27, 1937.

PLATE 7

A longitudinal section of the corm of a banana plant infected with the wilt, or the Panama disease. Note the similarity in appearance of the discolored area on the corm with that of the abacá, as shown in Plate 6. The specimen was collected from Upper Bayabas, 3,000 feet above sea level. Photographed March 17, 1937.

PLATE 8

A portion of a 6-hectare abacá plantation (Maguindanao variety) seriously infected with the abacá vascular disease. Taken at Gumati Plantation, 2,650 feet above sea level. Photographed March 17, 1937.

PLATE 9

A portion of an abacá field badly infected with the vascular disease. Note the diseased plants that were cut at the middle of the stalks preparatory to digging. Taken at Mindanao Reclamation Co., Tongkalan, Davao, 1,600 feet above sea level. Photographed March 17, 1937.

PLATE 10

A portion of an abacá plantation previously infected with the vascular disease. Note that all the diseased plants have been dug out, at Mindanao Reclamation Co., Tongkalan, Davao, 1,750 feet above sea level. Photographed March 17, 1937.

PLATE 11

Diseased abacá suckers detached from infected mother plant of the Maguindanao variety. Note the ramifying growth of mycelium at the cut portion 24 hours thereafter. The specimen was taken from Serib, Guianga District, about 2,500 feet above sea level. Photographed March 2, 1937.

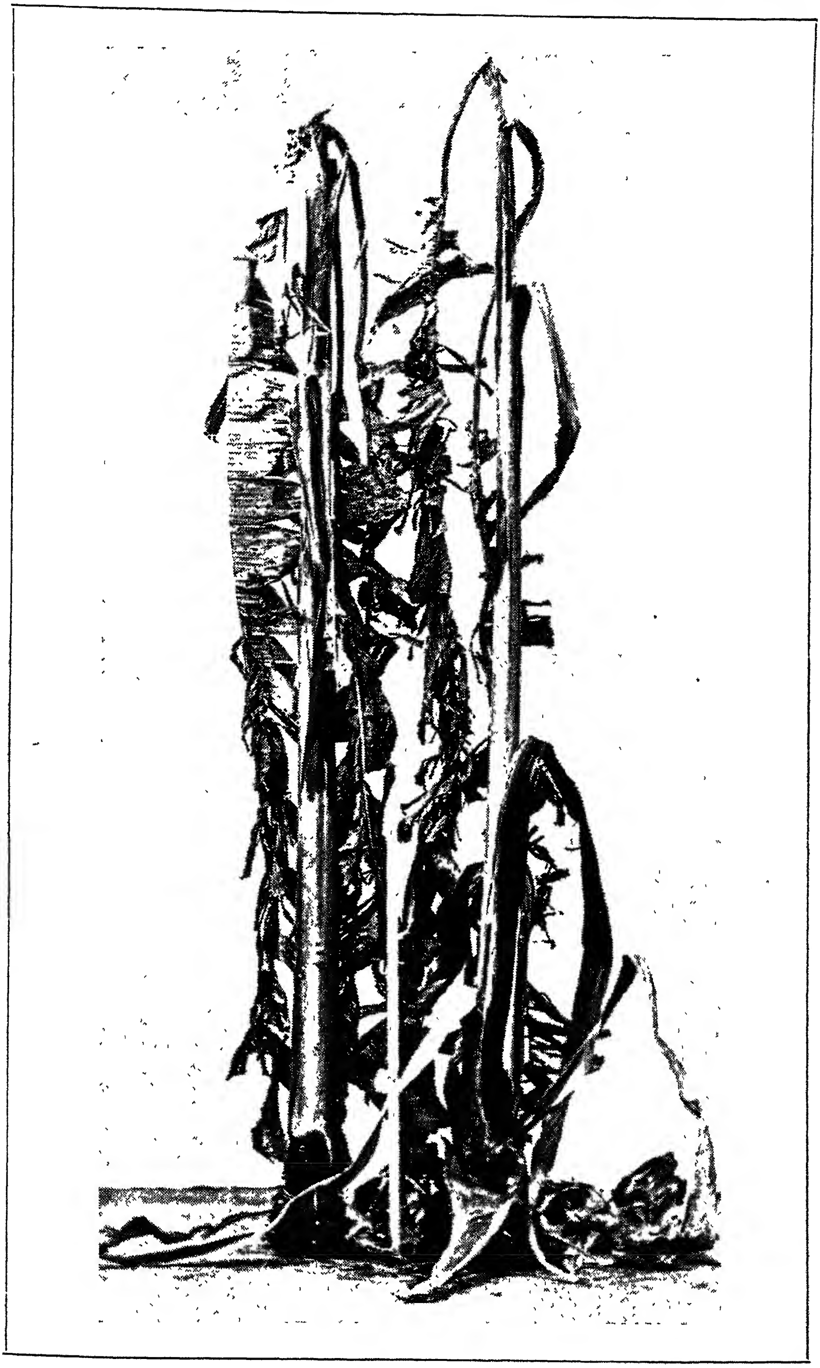

PLATE 1.

a *b*

PLATE 2

PLATE 3

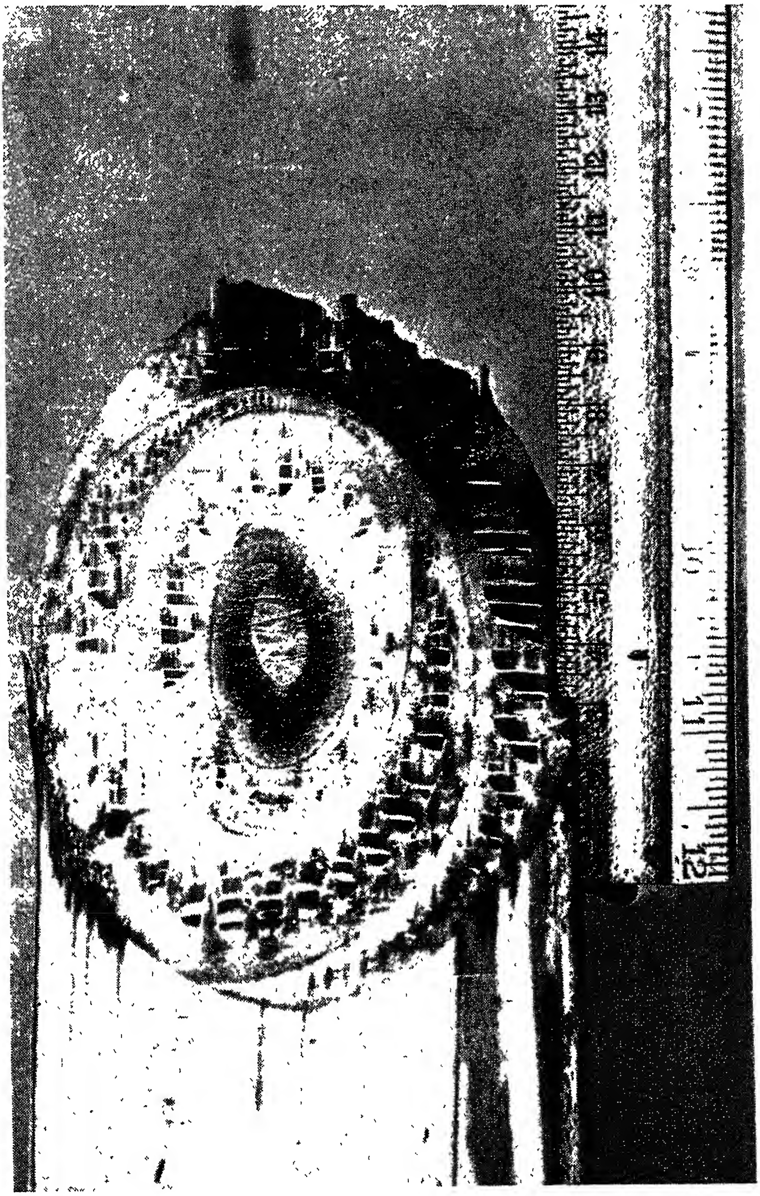

PLATE 4

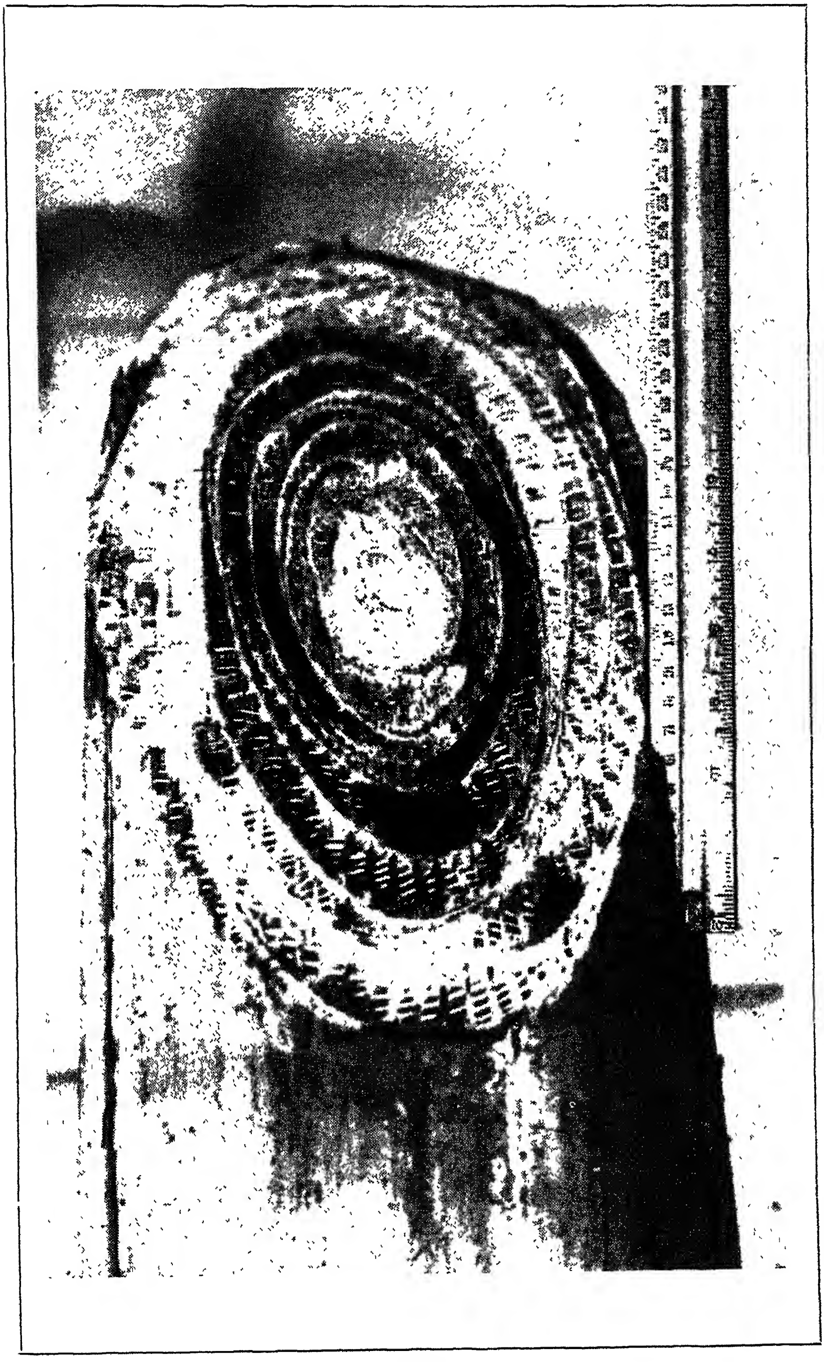

PLATE 5

PLATE 6

PLATE 7

PLATE 8

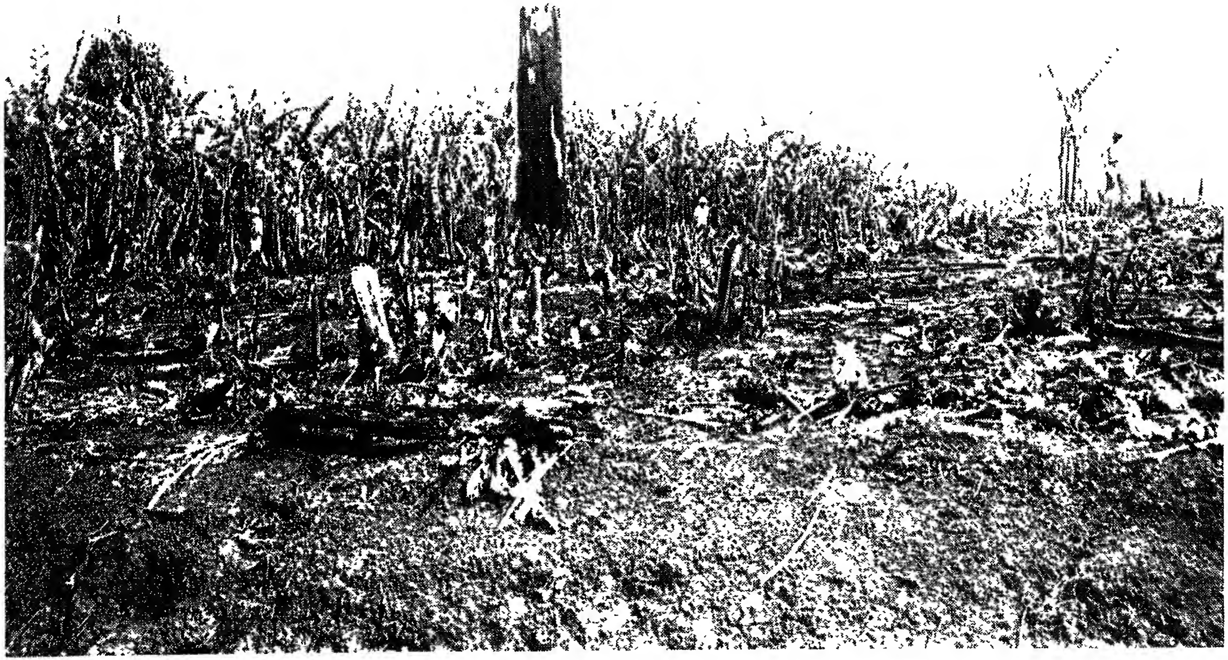

PLATE 9

PLATE 10

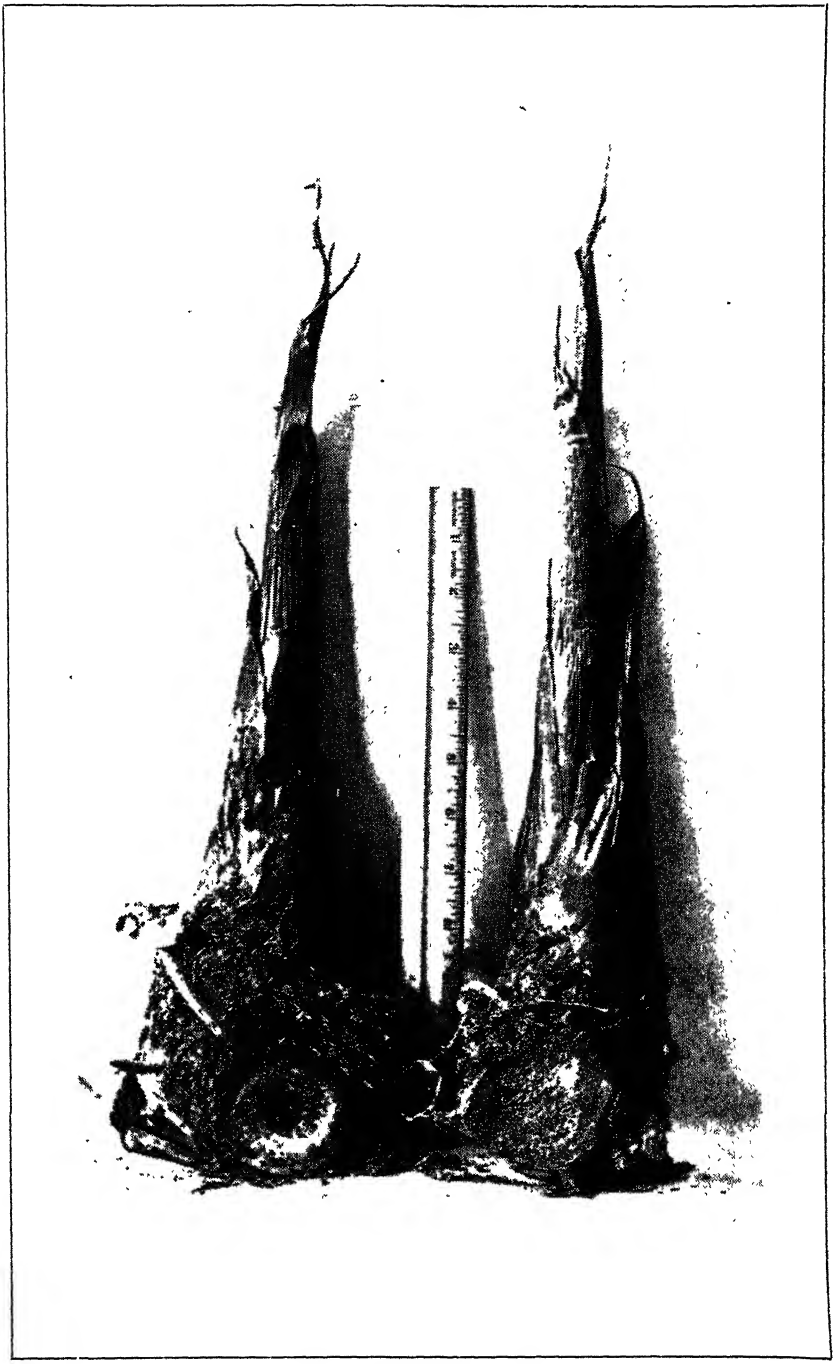

PLATE 11

RESULTS OF CITRUS HYBRIDIZATION IN THE PHILIPPINES

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The first report(1) on citrus hybridization dealt primarily with the study of pollination and its technique, including the care of crossed flowers and fruits and the resulting plants while yet in the seed flat. The merits and demerits of some of the important parent varieties were also discussed. A brief discussion of the results of hybridization from 1928 to 1931 was also given.

In a more recent report(2), however, the nature of some of the materials used in hybridization as regards the number of embryo in the seed, was described. In addition, some of the important processes were briefly described with respect to their juvenile or transient characteristics, which were used to differentiate the hybrids from the non-hybrids or apogamous seedlings on the seed parents.

The present report gives further data and notes on citrus hybridization, including the results obtained during the last nine years. In order to devote the allowed space entirely for the discussion of the results of hybridization, the propagation and the planting of citrus hybrids in the testing orchards will be discussed in a separate article under the caption, "Propagation and Planting of Philippine Citrus Hybrids," to be published in a latter issue of this journal.

RESULTS

Prior to 1931 flowering season, only the successful crosses had been duly recorded and the failures were briefly accounted for. Seventy one crosses using 500 crossed flowers were then made, of which, only 6 crosses came out successful. The general failure was attributed to the more or less faulty or imperfect technique and to the fact that few flowers were used in most of the crosses, thus making no allowance for the natural falling of fruits due to physiological, pathological, or other troubles.

All the successful crosses produced in 1929 and 1930 are shown in Table 1, and the results of hybridization work from 1931 to 1936 flowering seasons, inclusive, are given in Tables 2, 3, 4, 5 and 6, respectively. The summary of the results is presented in Tables 7 (a) and 7 (b). The successful intraspecific and interspecific crosses are diagrammatically indicated in figure 1.

DISCUSSION OF RESULTS

The results of 1931 hybridization may be reviewed very briefly. There were 27 crosses with a total of 1,039 cross-pollinated flowers. Of the 11 intraspecific crosses, six were successful and of the 16 interspecific crosses, 3 came out successful. The large percentage of crosses which failed in that year was attributed to the rindborer *Prays citri*, which attacked the crossed

TABLE 1.—*Successful citrus crosses prior to 1931.*

Crosses	Date pollinated	No flowers	No. fruits	No seed	No seed-giving	No seed ling	Number hybrids	
							Total	Selected
Szinkom mandarin x Bat. mandarin	2-12-29	26	9	(b)	(b)	16	3	2
Batangas x Szinkom	2-12-29	11	2	(b)	(b)	[a] 1	------	------
Szinkom x King mandarin	3-18-30	3	1	(b)	(b)	[a] 12	------	------
Orange N. 10 x Kishiu	1-29-29	2	1	(b)	(b)	[a] 5	------	------
Siamese 3442 x Saigon pomelo	5-19-30	11	10	(b)	62	62	62	17
Siamese 3442 x Vermilion pomelo	5-14-30	8	3	(b)	74	74	74	27

[a] Lost. (b) No record.

flowers and fruits at a young stage. Since all the crossed fruits had been allowed without any protective covering, the results obtained may serve as a measure of the relative susceptibility of the different seed parents to the rindborer. At that time, rindborers were specially abundant in the station, and were observed to have attacked severely the sweet oranges, pomelos, and limes. The mandarins and the lemons were the least attacked by these insects. Among the pomelos, Nueva Ecija P. I. No. 3910B had shown the greatest resistance. The failure of the crosses of Villafranca lemon with Thornless lemon and Siamese 3442 was due to the gumming disease which killed the branches before any of the crossed fruits reached maturity.

The foregoing results emphasize the fact that in hybridization, it is imperative to use certain protective covering, like cheese

cloth, so that the insects may be prevented from attacking the crossed flowers and young fruits and that healthy branches and twigs on which to perform hybridization should be carefully selected.

1932 Citrus hybridization.—In the 1932 flowering season there were 16 successful and 7 unsuccessful crosses embracing 719 crossed flowers (Table 3). In fact all the 23 crosses may be

TABLE 2.—*Results of 1931 citrus hybridization.*

Crosses	Date pollinated	No. flowers	No. fruits	No seed	No seed giving	No. seedling	Number hybrids: Total	Number hybrids: Selected
INTRASPECIFIC CROSSES								
King mandarin x Batangas mandarin	5-22-31	39	11	[d]	179	174	179	15
Szinkom mandarin x Batangas mandarin	5-23-31	91	12	[d]	319	499	91	31
Szinkom x King [e]	5-23-31	25	5	[d]	50	68	26	10
Szinkom x Tizon mandarin	5-25-31	38	12	[d]	130	167	48	28
Panuban grapefruit x McCarthy grapefruit	5-30-31	12	3	[d]	70	78	58	1
Siamese 3442 x Nueva Ecija pomelo	5-29-31	33	[a] 3					
Vermilion x Siamese 3442	5-29-31	8	[a] 5					
Wash. Navel x Laurel orange	5-22-31	146	[a] 5					
Wash. Navel x Orange N. 10	5-22-31	99	[b]					
Villafranca lemon x Thornless lemon	5-28-31	22	[c] 18					
INTERSPECIFIC CROSSES								
Bahia orange x Batangas mandarin	5-26-31	76	[a] 1					
Bahia x King mandarin	5-26-31	45	[b]					
Bahia x Tizon mandarin	5-20-31	19	[b]					
Wash. Navel x Tizon mandarin	5-25-31	20	[b]					
Bahia x Siamese 3442	5-26-31	81	[b]					
Bahia x Villafranca lemon	5-26-31	85	[b]					
Siamese 3673 pomelo x King mandarin	5-25-31	20	2	[d]	108	108	108	9
Siamese 3673 pomelo x Batangas	5-27-31	11	[b]					
Nueva Ecija x Bahia orange	5-27-31	12	[b]					
Siamese 3673 x Bahia orange	5-27-31	37	[b]					
Vermilion pomelo x Bahia orange	5-28-31	12	[b]					
Nueva Ecija pomelo x Thornless	5-29-31	14	[b]					
Siamese 3673 x Villafranca	5-27-31	12	[b]					
Villafranca lemon x Bahia orange	5-28-31	2	1	[d]	21	22	15	3
Villafranca lemon x Nueva Ecija pomelo	6-28-31	17	5	[d]	72	82	39	12
Villafranca x Siamese 3442	5-28-31	13	[c] 1					

[a] Dropped. [b] None set. [c] Branch diseased. [d] No record. [e] Second cross.

considered successful in so far as the production of crossed seeds is concerned. However, 2 of the 7 nobilis crosses, the Szinkom × China and the Szinkom × Kishiu, failed because the seeds were totally destroyed overnight in the germinating boxes by the black ants known in Tagalog as *quetib*. In this report the terms *mandarin crosses* and *nobilis crosses* are used interchangeably.

The crosses in which grapefruits were used, either as seed parent or pollen parent, produced rather weak hybrid seedlings that were highly susceptible to damping-off and to citrus canker *Pseudomonas citri*. In view of this fact only a few of the hy-

TABLE 3.—*Results of 1932 citrus hybridization.*

Crosses	Date pollinated	No flowers	No. fruits	No. seed	No. seed-giving	No. seedling	Number hybrids	
							Total	Selected
CITRUS NOBILIS CROSSES								
Kishiu x Bat. 8865	6– 3–32	63	1	12	12	12	12	2
Kishiu x China	6– 5–32	30	2	36	33	33	33	2
Kishiu x Dancy	6– 3–32	100	17	142	107	107	107	1
Kishiu x King	6– 3–32	75	5	44	37	37	37	5
Kishiu x Szinkom	3– 9–32	35	10	136	24	24	24	8
Szinkom x China	6– 4–32	12	2	[a] 67	------	------	------	------
Szinkom x Kishiu	6– 4–32	16	2	[a] 78	------	------	------	------
C. MAXIMA CROSSES								
Pink x La Union	6– 8–32	14	1	77	82	82	82	2
Pink x Siamese 3442	6– 4–32	12	4	192	181	181	181	3
Pink x Siamese 3673	6– 8–32	16	1	111	103	103	103	3
Siamese 3442 x Pink	6– 6–32	45	5	416	394	394	394	3
C. OVUCARPA CROSS								
Panuban x Marsh	6– 4–32	40	1	18	2	[b] 2	------	------
C. MAXIMA X C. OVUCARPA								
Pink x Marsh	6– 7–32	24	2	150	136	136	136	2
Pink x Panuban	6– 8–32	22	1	57	6	[b] 6	------	------
Siamese 3442 x Panuban	6– 7–32	5	1	100	93	93	93	4
Siamese 3442 x Duncan	6– 8–32	21	1	125	108	108	108	3
Siamese 3442 x Marsh	6– 5–32	13	2	49	45	45	45	2
OTHER INTERSPECIFIC CROSSES								
Kishiu mandarin x Jaffa orange	3–26–32	39	2	10	1	[b] 1	------	------
Kishiu mandarin x Laurel orange	6– 3–32	90	4	41	35	[b] 35	------	------
Kishiu mandarin x Panubang grapefruit	3–12–32	10	2	12	4	[b] 4	------	------
Szinkom mandarin x Laurel orange	6– 4–32	19	11	215	5	[b] 5	------	------
Villafranca C. x Kusaie lime	6– 7–32	7	2	29	29	29	7	3
Siamese 3442 x Laurel orange	6– 5–32	11	1	90	82	82	82	5

[a] Seed destroyed by ants. [b] Died.

brids were selected for propagation and planting for further study.

All seedlings from the crosses of Panuban × Marsh, Pink × Panuban, Kishiu × Jaffa orange, Kishiu × Laurel orange, Kishiu × Panuban, and the Szinkom × Laurel orange died of damping-off disease several days after germination. As the seeds and hybrid seedlings are destroyed by ants, damping-off disease and citrus canker, it is desirable to take extremely good

TABLE 4.—*Results of 1933 citrus hybridization.*

Crosses	Date pollinated	No. flowers	No. fruits	No. seed	No. seed-giving	No. seed-ling	Number hybrids	
							Total	Selected
C. NOBILIS CROSSES								
China x Batangas 8865	5-15-33	53	25	212	160	327	69	31
China x King	5-17-33	71	34	196	122	233	57	16
China x Tizon	5-17-33	129	43	225	152	308	25	20
King x Calamandarin	5-19-33	27	15	175	149	156	149	32
King x Kishiu	5-15-33	41	25	259	223	227	223	60
King x Ladu	5-15-33	96	35	380	280	287	280	54
King x Szinkom	5-17-33	30	9	50	43	43	43	16
King x Tizon	5-13-33	36	20	75	61	61	61	17
Kishiu x Ladu	5-18-33	32	(d)	------	------	------	------	------
Kishiu x Tizon	5-14-33	20	(d)	------	------	------	------	------
Ladu x Batangas 8865	5-18-33	36	16	296	267	582	71	31
Ladu x King	5-17-33	28	5	76	66	155	25	21
Ladu x Kishiu	5-18-33	25	7	77	67	186	63	50
Ladu x Szinkom	5-17-33	23	5	46	36	150	11	10
Szinkom x China [a]	5-16-33	42	17	227	156	248	49	21
Szinkom x King [b]	5-18-33	13	6	76	53	78	11	1
Szinkom x Ladu	5-15-33	128	46	751	592	857	79	18
Tizon x King	5-19-33	35	2	(e)	------	------	------	------
Tizon x Ladu	5-20-33	41	19	25	15	29	12	11
C. LIMONIA CROSS								
Villafranca x R. lemon	5-20-33	10	1	11	8	8	3	1
C. SINCURIS CROSS								
Wash. Navel x Laurel	5-20-33	83	6	36	32	64	20	[e] 3
INTERSPECIFIC CROSSES								
Calamonding x Ladu mandarin	5-17-33	53	36	270	143	270	60	20
Calamonding x Szinkom mandarin	5-17-33	47	29	72	40	92	18	None.
Kishiu x Calamonding	5-14-33	71	(f)	------	------	------	------	------
Szinkom x Calamonding	5-12-33	74	14	238	162	292	27	20
Tahiti lime x Lemon	5-20-33	3	1	(e)	------	------	------	------
Szinkom x Laurel [a]	5-13-32	36	9	124	96	146	15	11

[a] Second cross. [b] Third cross. [c] Still in the nursery.
[d] Branch diseased. [e] Seedless. [f] None set.

TABLE 5.—*Results of 1934 citrus hybridization.*

Crosses	Date pollinated	No. flowers	No fruits	No seed	No. seed-giving	No seedling	Number hybrids Total	Number hybrids Selected
CITRUS NOBILIS CROSSES								
King x Batangas B87	3-15-34	195	19	357	157	166	157	11
King x Dancy	3-16-34	118	38	800	563	576	563	36
King x Szinkom	3-16-34	130	20	233	120	128	120	7
King x Tizon [a]	3-16-34	36	8	100	62	64	62	9
Kishiu x Batangas B87	3-15-34	29	4	54	18	18	18	6
Kishiu x Batangas k4	3-14-34	74	4	61	27	27	27	10
Kishiu x Batangas k23	3-14-34	167	3	29	1	1	1	1
Kishiu x Batangas 8865 [a]	3-14-34	79	6	73	52	52	52	9
Kishiu x King [a]	4-26-34	15	(b)	------	------	------	------	------
Kishiu x Tizon [a]	4-26-34	31	3	15	4	[d] 4	------	------
Szinkom x Tizon	3-16-34	182	32	363	30	30	30	[f] 1
Szinkom x Batangas B87	3-13-34	146	(i)	------	------	------	------	------
Szinkom x Batangas k4	3-13-34	75	4	109	50	72	15	13
Szinkom x Batangas k23	3-13-34	134	9	115	45	64	30	10
C. AURANTIFOLIA CROSS								
Kusaie x Native lime	3- 4-34	66	15	43	13	13	13	4
INTERSPECIFIC CROSSES								
Chinese pomelo x sour orange	3- 9-34	28	[e] 1	------	------	------	------	------
Chinese x R. Lemon	3- 9-34	26	(g)	------	------	------	------	------
Eureka lemon x Native lime	3- 8-34	11	(g)	------	------	------	------	------
Kishiu x Calamonding [a]	4-26-34	35	1	6	6	[d] 6	------	------
Kishiu x R. lemon	3- 4-34	61	(g)	------	------	------	------	------
Lui Gim Gong orange x Kishiu	3- 4-34	40	1	8	8	[d] 8	------	------
Lui Gim Gong x R lemon	3- 5-34	71	(g)	------	------	------	------	------
Magnum Bonum x R. lemon	3-20-34	362	20	275	(h)	(h)	24	[f] 10
R. lemon x Sour orange	3- 8-34	192	139	2,110	819	1,607	38	6
Sour orange x R. lemon	3-19-34	155	13	647	319	385	56	(j)
Daidai x R. lemon	3- 5-34	68	(g)	------	------	------	------	------
Szinkom mandarin x R. lemon	3- 4-34	61	29	571	(h)	(h)	20	[f] 8
Siamese 3142 x R. lemon	3- 9-34	30	(g)	------	------	------	------	------
Siamese 3442 x Florida sour orange	3- 9-34	30	1	117	101	102	102	[f] 9
Villafranca lemon x Native lemon	3- 8-34	26	3	34	2	2	2	1
Kusaie lime x Eureka lemon	3- 4-34	10	3	15	3	3	3	3

[a] Second cross.
[b] Branch destroyed by wind.
[d] Died.
[e] Lost.
[f] Still in the nursery (8-31-3).
[g] None set.
[h] No record.
[i] Branch diseased.
[j] None.

care of the seeds and to disinfect or to sterilize the soils to be used for germinating these valuable crossed seeds. The failure to obtain healthy hybrid seedlings from 7 out of the 23 citrus crosses made in the 1932 flowering season was due to no other

cause than the lack of care of the seeds and young seedlings in the seed flats. In passing, it may be stated that in order to prevent damping-off, the soil in the seed flats should be sterilized thoroughly with hot or boiling water before sowing the seeds(1). The citrus canker may be easily prevented by spraying the seedling at close intervals with either Bordeaux mixture or lime sulphur solution(2).

1933 *Citrus hybridization.*—There had been attempted 27 different crosses during the flowering season of 1933, which comprised 1,283 cross-pollinated flowers (Table 4). Of the 19

TABLE 6.—*Results of 1935 and 1936 citrus hybridization.*

Crosses	Date pollinated	No. flowers	No. fruits	No. seed	No. seed-giving	No. seed-ling	No. Hybrids	
							Total	Selected
CITRUS NOBILIS CROSS								
Kishiu x Ladu [a]	6-20-36	64	3	24	22	22	22	(b)
INTERSPECIFIC CROSSES								
Siamese 3442 x Laurel mandarin oranges [a]	3-13-35	76	12	196	144	144	144	[d] 31
Siamese 3442 x Dougat mandarin oranges	3-14-35	64	8	170	126	126	126	[d] 32
Siamese 3442 x Du. Roi. mandarin oranges	3-11-35	35	7	138	115	115	115	[d] 24
King mandarin oranges x Dougat mandarin oranges	3-10-35	37	4	75	50	52	50	9
King mandarin oranges x Laurel mandarin oranges	3-13-35	77	[e] 10					
King mandarin oranges x Dougat oranges [a]	6-20-36	65	27	120	119	131	119	(b)
Ladu mandarin oranges x Laurel mandarin oranges	6-20-36	158	34	382	344	644		

[a] Second cross.
[b] Seedlings still in seedbox.
[c] Hybrids not yet determined.
[d] Still in nursery.
[e] Fruits missing.

nobilis crosses, three were considered failure. The Kishiu × Ladu and Kishiu × Tizon crosses failed to produce fruits on account of the unexpected death of the branches bearing the crossed flowers, caused by a sudden attack by a severe pink disease. The Tizon × King cross gave two normal ripe fruits from 35 cross-pollinated flowers but without well-developed seeds. Tizon is a semiseedless variety, which may account for the failure of the seed to develop normal fruits. On the other hand, in the reversed cross, King × Tizon, there were produced 20 fruits out

of 36 crossed flowers, indicating that the Tizon × King is a case of cross incompatibility in only one direction. The Tizon × Ladu cross gave 19 matured fruits out of the 41 cross-pollinated flowers and only a total of 25 seeds. Seven of the fruits were without normal seeds showing partial sterility, producing a little better than one normal seed per fruit on the average.

The Kishiu × Calamonding cross produced no fruit from the 71 cross-pollinated flowers. These results tend to show cross-incompatibility at least in that direction. On the other hand, using Calamonding as seed parent, as in the crosses of Calamonding × Ladu and Calamonding × Szinkom, a good number of normal crossed fruits developed and a good number of hybrid seedlings were produced. The cross of Tahiti × Rough Lemon, consisting of three crossed flowers, produced one fruit without seed. Being a seedless variety of lime, the Tahiti may be expected to produce no normal seed. However, the experiment should be repeated, using a greater number of crossed flowers to verify these results.

1934 *Citrus hybridization.*—In the 1934 flowering season there were made 14 nobilis crosses, one aurantifolia cross and sixteen interspecific crosses (Table 5,), or a total of 31 different crosses embracing 2,683 cross-pollinated flowers. Of the 16 nobilis crosses, the Kishiu × King failed to set, because the branch broke off due to wind. The loss of the Szinkom × Batangas B87 was due to a sudden attack by severe pink disease on the branch bearing the crossed flowers. In the light of these losses, the selection of a branch which is healthy and strong enough to resist strong winds and the proper treatment of the branches in order to prevent any sudden attack by pink or other bark-rot diseases that might hamper the expected result, become important. As a preventive measure against any of these bark troubles, dressing the branches and trunks with lime sulphur paste will serve the purpose.

Of the sixteen interspecific crosses, no setting of fruits was found in the following six crosses: Chinese pomelo × R. lemon; Liu Gim Gong orange × Rough lemon; Siamese 3442 × Rough lemon; and Satsuma No. 2 or Daidai × Rough lemon. These failures may be considered cases of cross incompatibility, but they need further verification by using a greater number of crossed flowers. The young F1 hybrids from the crosses of

Kishiu × Calamonding (II) and Lui Gim Gong × Kishiu were very weak and highly susceptible to the attack of damping-off and citrus canker, to which their total failure to grow further was attributed. Young hybrids from the cross of Sour orange × Rough lemon were also found very weak.

1935 and 1936 Citrus hybridization.—There had been made one nobilis cross, Kishiu × Ladu, and seven interspecific crosses in the flowering seasons of 1935 and 1936, which covered 576 cross-pollinated flowers. Seven crosses in all came out successful, from which were obtained 1,105 seeds, 920 of which germinated, giving 1,234 seedlings. The fruits from the cross of King × Laurel orange were found missing.

GENERAL DISCUSSIONS

During the last nine flowering seasons, 187 different citrus crosses were made, 77 of which or about 41.2 per cent came out successful. Apparently, the greatest failure occurred during the first three flowering seasons. This great loss, as stated above, was due primarily to a more or less imperfect technique used and the lack of sufficient number of crossed flowers in many cases, not excluding the attack of rindborer on the crossed flowers and fruits. Due to the improvement attained in the technique, there had been a gradual increase in the percentage of success from 1931 to 1933 flowering season (see column 4 Table 7 [a]). However, there was a big drop in the percentage of successful crosses in 1934 due to the fact that in that season

TABLE 7(*a*).—*Results of citrus hybridization from 1928 to 1936 flowering seasons, inclusive.*

Year	Number of crosses			No. flowers	No. fruits	No. seed	No. seed-giving	No. seed-lings	No. hybrids	
	Total	Successful							Total	Select-ed
		No.	Per cent							
1928–30	71	6	8.4	500	26	(a)	[b] 136	170	136	46
1931	27	9	33.3	1,039	58	(a)	1,365	1,634	980	141
1932	23	15	65.2	719	80	2,227	1,519	1,519	1,444	49
1933	27	22	81.4	1,283	429	3,917	2,923	4,799	1,371	464
1934	31	18	58.1	2,683	377	6,085	2,401	3,328	1,328	154
1935–36	8	7	87.5	576	105	1,105	920	1,234	576	118
Total	187	77	41.2	6,800	1,075	[b] 13,334	[b] 9,264	12,684	5,835	972

[a] No record. [b] Incomplete.

16 of the 31 crosses attempted were interspecific crosses, nine of which failed. Some of the crosses did not set, while others produced very weak hybrid seedlings, so weak that they were all destroyed by the damping-off disease and citrus canker at the early stage.

In Table 7(b), it can be seen that from the 1931 to 1936 flowering seasons, there were made 45 mandarin crosses, 7 pomelos, 2 grapefruits, 3 oranges, 2 lemons, 1 lime, and 56 crosses between species.

Mandarin crosses.—Of the 45 mandarin crosses, 37 or 82.2 per cent were successful and 8 crosses or 17.8 per cent were failures. Total destruction of seeds by ants accounted for the loss in 1932 of the Szinkom × China and the Szinkom × Kishiu, while the sudden attack by a severe pink disease on the branches bearing the crossed flowers accounted for the loss in 1933 of the Kishiu × Ladu and the Kishiu × Tizon and of the Szinkom × Batangas B87 in 1934. The loss, in 1934, of Kishiu × King (II) was due to the destruction of the branch, and that of the Kishiu × Tizon was attributed to the weak hybrid seedlings which were killed by the damping-off disease. Based upon the results obtained from the hybridization of mandarins, it may be inferred that the different varieties are cross-compatible. The significance of this hybridization study points to the fact that in an orchard of mixed varieties of mandarins, cross-fertilization is highly probable to occur, since they are as a rule cross-compatible.

TABLE 7(*b*).—*Kind of crosses attempted from 1928 to 1936 inclusive.*

Kind of crosses	Total	Number of crosses		Remarks
		Successful	Failure	
Mandarins	45	37	8	Failure due to nongenetic causes.
Pomelos	7	5	2	Do.
Grapefruits	2	1	1	Do.
Oranges	3	1	2	Do.
Lemons	2	1	1	Do.
Lime	1	1	0	
Interspecific	56	25	31	Six failures due to cross-incompatibility.
Miscellaneous 1928–30	71	6	65	Four failures due to cross-incompatibility.
Total	187	77	110	Ten failures due to cross-incompatibility.

Pomelo crosses.—There were five successful crosses, and two crosses failed because of the rindborers which attacked the young fruits. Like the mandarins, the different varieties of pomelos may be regarded as cross-compatible with each other. The pomelos are monoembryonic, and all seedlings produced are from sexual embryos. Considering the fact that they are highly susceptible to cross-fertilization, it is, therefore, reasonable to expect many of the seedlings not to come out true to the type of the mother tree.

Other intraspecific crosses.—From the fact that both the Panuban grapefruit × McCarthy grapefruit and the Panuban × Marsh produced hybrid seedlings, it may be inferred that these varieties are cross-compatible. With oranges, the failure of Washington Navel × Laurel and Washington Navel × Orange No. 10 crosses in 1931 was attributed to the attack by the rindborers. It is believed that orange varieties may be crossed with each other easily, but the hybrids are indeed difficult to be sorted out from among the apogamous seedlings. The same was true with lemons and limes if crosses were made between varieties of the same species. Cross-compatibility between varieties of the same species is the rule in citrus and only one out of 60 varietal crosses presented here tends to show a doubtful case of cross-incompatibility. The Tizon × King may be considered a doubtful case of cross-incompatibility because the Tizon × Ladu cross had produced 19 fruits from 41 cross-pollinated flowers. Seven of the mature fruits were found seedless, while 12 fruits gave 25 normal seeds or a little over two seeds on the average: With more fruits than two produced from the cross of Tizon × King, similar result could have been obtained.

Interspecific crosses.—From the 56 species crosses, 25 crosses or 44.6 per cent were successful and 31 or 55.4 per cent were failures. Eleven species crosses failed most probably due to the attack of rindborers, inasmuch as no covering was employed after cross-pollination. In the later seasons, using cheese cloth as cover, the following crosses did not set fruits: Kishiu × Calamonding; Chinese pomelo × Rough lemon; Eureka lime × Native lime; Kishiu × Rough lemon; Lui Gim Gong orange × Rough lemon; Daidai × Rough lemon; and Siamese 3442 pomelo × Rough lemon. Those that died at the seedling stage on account of weak seedlings produced were: Pink pomelo × Panuban grapefruit; Kishiu mandarin × Jaffa orange; Kishiu × Laurel orange; Kishiu × Panuban; Szinkom mandarin × Laurel

orange; Kishiu × Calamonding (II); and Lui Gim Gong orange × Kishiu. The failure of four other species crosses was due to loss of fruits and death of the branches.

Cross-incompatibility in citrus.—Jones (5) defined incompatibility as the inability to accomplish fertilization in a particular mating. According to him, sterility resulting from incompatibility occurs when the parents crossed are alike with respect to particular sterility factor and also when they are germinally so dissimilar. Since citrus are generally self-fertile, the sterility factor theory as a cause of cross-incompatibility is out of consideration, thus giving favor to the theory of genetic differences. In avocado there are varieties that are cross-incompatible, others are compatible in only one direction while others had been successfully crossed either way (6), while in citrus, there is no clear-cut cross-incompatibility between varieties of the same species, but there are some varieties of different species that were found to be cross-incompatible. Other varieties, even though of different species, are cross-compatible. Refer to the diagram, Figure 1.

The results of interspecific hybridization show that the different species of citrus are to a certain extent cross-compatible, depending upon the varieties used in the cross. Mandarins were crossed successfully with Calamonding, oranges, grapefruits and lemon; Calamonding with mandarins; oranges with mandarins and lemon; sour orange with lemon; pomelos with mandarin oranges, sour oranges, and grapefruits; lemon with sour orange, pomelo with limes; and lime with lemons. However, it may be remembered that there are specific instances in which cross-incompatibility has been exhibited, as in the crossing of Siamese 3442, Chinese pomelo, Kishiu mandarin, Lui Gim Gong orange, Daidai, and Tahiti lime with Rough lemon. To these may be added the several attempts in 1930 to cross Siamese 3442 and Siamese 3673 with Kishiu mandarin and Calamonding and the King with Calamonding which also failed to bear fruits. Because of the fact that the hybrids produced were weak and died at a young stage, hence the crosses of Kishiu with Calamonding, Tizon, Jaffa, and Laurel oranges might be included in the group of cross-incompatible varieties, at least in the direction stated.

SUGGESTIONS REGARDING CITRUS HYBRIDIZATION

Based on the present and previous reports on the results and observations during the last nine flowering seasons, the

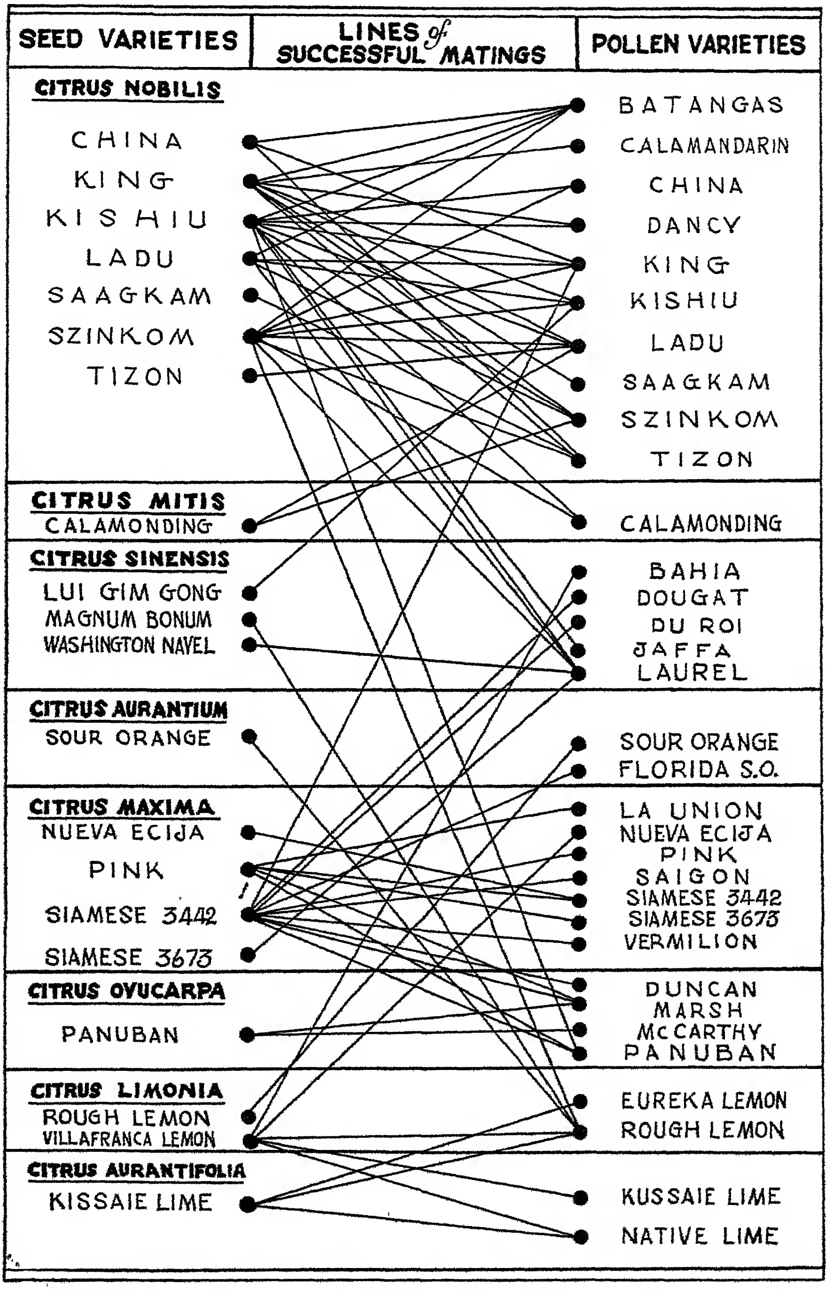

FIG 1.—Diagram showing successful intraspecific and interspecific citrus crosses.

following considerations may be important in connection with citrus hybridization.

1. Use the monoembryonic or the less polyembryonic types of citrus for seed parents and the polyembryonic ones as pollen parents. Polyembryonic varieties may be used as seed parents provided that the resulting F1 hybrid seedlings are easily recognizable from the apogamic seedlings of same.

2. Use for seed parents the varieties with tight articulation, i. e., less subject to windfall.

3. Select the healthy and strong branches and twigs on which to perform hybridization and apply from time to time a dressing of lime sulphur paste on the branches so as to prevent any sudden attack by pink or other bark diseases.

4. Study carefully the behavior of the parents with special reference to the time of opening of the flower, receptiveness of the stigma, and dehiscence of the pollen.

5. Emasculate the flowers in the afternoon preceding the day of opening and cover with cheesecloth bags the branches bearing the emasculated flowers. Emasculation may be done properly in the morning as the flowers begin to open or some hours before the pollen grains dehisced. There are varieties which open their flowers almost simultaneously with dehiscence. In those cases, emasculation should be done earlier.

6. Pollen is collected by picking flowers of the pollen parents that are about to open. When picked in the afternoon the pollen grains are ready for crossing on the following morning.

7. Use sufficient number of flowers, say 50 or more flowers for each cross, in order to insure setting of fruits.

8. Cover the cross-pollinated flowers with cheese cloth to protect them from contact with astray pollen and from the attack by rindborers and other insect pests.

9. Protect the crossed fruits from the attack by rindborers, green bugs, and other insect pests and citrus canker.

10. The crossed fruits may be harvested as soon as the fruits mature, not yet ripe.

11. After carefully extracting the seeds from the fruits, wash the seeds with clean water and spread and air-dry them for two hours or so before planting in seed flats.

12. Sterilize twice the soil in the seed flat with boiling water, taking care not to wash away the fertility of the soil. Sandy loam with well-rotted compost is the best soil compound for germinating the seeds.

13. Plant the seeds in the seed flats 2 to 3 centimeters apart and about one-half to one centimeter deep.

14. Give a thorough watering to the seed flats so as to insure a good start in germination and do not water while the seeds are germinating, unless the condition so warrants.

15. After germination keep the flats moist or well watered every day to obtain a normal rate of growth of the seedlings.

16. Prevent the outbreak of canker by applying from time to time either lime sulphur spray or Bordeaux mixture solution.

17. Observe the appearance of the seedlings as they grow in the seed flats and determine and study the differences between the hybrids and the apogamous seedlings or the check prepared for the purpose.

18. After four to six months, depending upon the size attained by the plants, select the hybrid seedlings for pricking either in pots, in seed flats or in beds. If pricking is done in seed flat, the distance should be 8 to 10 centimeters between the plants. In the seed flat, they may be allowed for several months until the weather and nursery conditions are favorable for transplanting them in the nursery beds where they are to be set about 40 to 50 centimeters apart.

SUMMARY

The results of citrus hybridization from 1929 to 1936 are here presented. Out of 187 crosses 77 were successful. Of the 45 mandarin crosses 37 were successful; of the 7 pomelos, 5; of 2 grapefruits, 1; of 3 oranges, 1; of 2 lemons, 1; one lime; and of the 56 interspecific crosses 25 were successful.

The results of intraspecific hybridization or mating of varieties from the same species indicate that cross-compatibility between varieties of the same species is the rule in citrus, whereas the results of interspecific hybridization show that the different species of citrus are cross-compatible to a certain extent, depending upon the varieties used in the cross.

Specific instances of cross-incompatibility between some varieties of different species are found in the matings of Siamese 3442, Chinese pomelo, Kishiu mandarin, Lui Gim Gong orange, Daidai, and Tahiti lime as seed parents with Rough lemon and in the direct and reciprocal crosses of Siamese 3442 and Siamese 3673 with Kishiu and Calamonding. The matings of Kishiu as seed parent with Calamonding, Tizon, Jaffa orange, and Laurel orange had produced very few seeds and very weak hybrid seed-

lings which died at a young stage, hence may be included in the group of semi-incompatible or doubtful cross-incompatible varieties, at least in the direction stated.

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THE EFFECT OF TRANSPLANTING PRICKED AND UNPRICKED TOBACCO SEEDLINGS OF DIFFERENT AGES UPON GROWTH AND YIELD.

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THREE TEXT FIGURES

Generally, healthy and well-developed seedlings, when transplanted in the field, turn out to be healthy and well-developed matured plants. But with regard to size and age of tobacco seedlings best for transplanting, in order to produce the highest yield possible, tobacco growers are at variance. Garner (1920) and Paguirigan (1925) advise that tobacco seedlings 12.5 to 15 cm high should be transplanted, and state that seedlings take about two months to attain this size. Brewer (1910) also states that under favorable conditions tobacco plants should be large enough to be transplanted in from six to eight weeks old from the time of sowing. Recently, Dalupang (1934) concluded that "on the whole—the 30-day-old and 37-day-old seedlings produced greater yields and better quality of leaves than 44-day-old and 51-day-old seedlings." The present paper reports the effects upon the growth and yield of tobacco in transplanting different ages of pricked and unpricked seedlings. The standard varieties of the three types of tobacco were tried, namely, (1) Ilagan Sumatra cigar wrapper type (open grown); (2) Simmaba, cigar-filler type; and (3) North-Carolina Bright Yellow and Samsoun Bafra, cigarette-filler type (Virginia and Turkish tobacco respectively). The experiment was conducted at Los Baños Economic Garden, Los Baños, Laguna, during the years 1935 and 1936.

MATERIALS AND METHOD

SEEDBED

Preparation of seedbed.—A level ground 46 meters long and 12 meters wide was selected for seedbed. The field was plowed and harrowed two times. Twenty-eight plots of 1.0 meter wide and 11 meters long were laid out as seedbeds. Paths 50 cm

wide separated the plots. The surface soil of the paths was removed and placed on the seedbeds. The earth on the seedbed was raised about a foot above the general level of the field. Previous to planting or sowing any of the seedbeds, the soil was forked and pulverized.

Sowing and pricking.—One square meter at the extreme left end of the seedbed was sown to tobacco seeds at the rate of 0.20 gram per square meter. At the same time, the adjacent 5-square-meter area of the seedbed was also sown to tobacco seeds at the rate of 0.10 gram per square meter. When the seedlings were 28 days old (from sowing) on the seedbeds, ten average-sized seedlings in the 5-square-meter area were selected, tagged, and measured. Hundreds of seedlings in the 1-square-meter area, approximately the same in growth development particularly as to number of leaves as the ones selected and measured, were carefully dug out and pricked at 10 centimeters apart on the remaining 5-square-meter area (right end of the seedbed) of the seedbed. The pricked and unpricked seedlings in the 5-square-meter sections of the seedbed were allowed to develop there until they were transplanted on the field on December 26, 1935. The other seedbeds were planted and treated similarly, but the sowing of the seeds was done at later dates at weekly intervals. The following table shows the dates of sowing, pricking, transplanting, and ages of seedlings during transplanting time:

Date of sowing	Date of pricking	Date of transplanting	Ages of seedlings
			Days
October 1, 1935	October 29, 1935	All the seedlings were transplanted on the same date—December 26, 1935.	86
October 8, 1935	November 5, 1935		79
October 15, 1935	November 12, 1935		72
October 22, 1935	November 19, 1035		65
October 29, 1935	November 26, 1935		58
November 5, 1935	December 3, 1935		51
November 12, 1935	December 10, 1935		44

[1] Age of seedlings was computed from date of sowing to transplanting.

THE FIELD

Preparation of field and transplanting of seedlings.—A level field 48 meters wide and 62 meters long previously planted to beans was used. It was plowed and harrowed three times at biweekly intervals previous to planting it to tobacco.

On December 26, 1935, the field was divided lengthwise into two equal parts. The first half was designated as lot A and the other half, lot B. In lot A, 30 lengthwise furrows at 80 cm apart were laid out, after which the lot was divided crosswise into two sections, C and D. The first 15 furrows in section C were planted to Ilagan Sumatra seedlings. Fifty-two uniformly developed plants, spaced at 50 cm apart, were planted in each furrow. The plants planted in the first furrow were considered as border plants. The seedlings planted in the second and third rows were 86 days old, but pricked seedlings were planted in the second row, and the unpricked ones, in the third row. The fourth and fifth rows, the sixth and seventh rows, the eighth and ninth rows, the tenth and eleventh rows, the twelfth and thirteenth rows, and the fourteenth and fifteenth rows were also planted to tobacco, 79, 72, 65, 58, 51, and 44-day-old pricked and unpricked seedlings respectively, that is, the pricked and unpricked seedlings of the same age, alternating each other. The other 15 furrows in section C were planted to Samsoun Bafra. The number, distance between plants, treatment, and age of the seedlings transplanted were the same as those of the Ilagan Sumatra.

In Section D, fifteen furrows were planted to Simmaba. Fifty-two seedlings were also planted to a furrow, and spaced at 70 cm apart. Pricked and unpricked seedlings were planted. The ages of the seedlings employed were the same as those of Ilagan Sumatra planted in section C. With the same condition and in the same manner as in Simmaba, the remaining 15 furrows were planted to North Carolina Bright Yellow.

Lot B was a duplicate culture of lot A. The conditions and treatments given to lot A were followed in lot B.

Care of plants.—The transplanted seedlings were not shaded but were watered quite freely. Watering was done every other afternoon during a period of one week.

The spaces between the rows were plowed a week after transplanting, while the spaces between the hills were dug with hoes. The field was kept clean during the whole growth development.

OBSERVATION

On the seedbed.—Ten plants, each of pricked and unpricked seedlings from the 4 varieties used, were measured for growth development. The length of the leaf was measured from the

axil to the tip, and the measurement of the width was taken at its widest part. The length was multiplied by the width of each leaf, and the product is called "leaf product," which is used in this study as a measure of the vegetative growth development of the plant. The leaf products of all the leaves of the ten plants measured were added together, and the sum was divided by 10. The quotient represents approximately the average total leaf area of one plant.

Previous to transplanting the seedlings in the field on December 26, 1935, the following records were gathered: (*a*) Average total leaf product of green leaves, (*b*) average measurement of length and width of biggest leaf of a plant, (*c*) average height of seedlings, and (*d*) average circumference of stem.

On the field.—There was no rain during the first week after transplanting. After the end of the first week, the number of dead plants in a row was counted and the percentage of death based on 50 plants was calculated. Vacant spaces were replanted.

Thirty-two days after transplanting, 10 average-sized plants from each row of Ilagan Sumatra and Simmaba varieties were observed for (*a*) number of leaves produced, (*b*) measurement of length and width of largest leaf developed on a plant, and (*c*) total leaf product of green leaves of one plant. The other two varieties, Samsoun Bafra and North Carolina Bright Yellow, were not observed at this time.

One day previous to the first priming, all the green leaves of 10 average-sized plants from all the rows, both in lots A and B, were measured. Priming was started when the flower buds of the plants were appearing. Harvesting was continued thereafter at weekly intervals until all the leaves were gathered. Fresh and dry weight of all leaves harvested from twenty-five average-sized plants from each row were recorded.

RESULTS

The results of this experiment are presented in tabulated forms and grouped into three, namely, (*a*) growth rate development of pricked and unpricked seedlings on the seedbed (Tables 1, 2, 3, and 4); (*b*) the after effect of transplanting different sizes of pricked and unpricked seedlings on the field (Tables 5, 6, 7, 8 and 9); and (*c*) the effect of age upon growth and yield (Tables 10 and 11).

TABLE 1.—*Development of different ages*[a] *of pricked and unpricked Ilagan Sumatra seedlings on the seedbed at different times of the year.*

Date of sowing	Average total leaf products of seedlings						
	28 days old	49 days old		63 days old		77 days old	
		Pricked	Un-pricked	Pricked	Un-pricked	Pricked	Un-pricked
1935	*Sq cm.*	*Sq cm.*	*Sq cm.*	*Sq cm.*	*Sq cm.*	*Sq. cm.*	*Sq cm*
October 1	9.9	69.8	105.8	335.9	461.2	1,358.8	1,056.7
October 8	10.5	79.2	115.0	303.6	572.8	1,272.2	969.7
October 15	11.8	65.5	140.7	329.0	597.8		
October 22	10.0	74.2	124.5	320.2	566.0		
October 29	9.0	70.5	104.7				
November 5	9.5	64.0	111.2				
November 12	9.4						
Average	10.10	70.5	117.0	322.2	549.5	1,315.5	1,012.2

[a] Seedlings were pricked when they were 28 days old from the date of sowing.

TABLE 2.—*Development of different ages*[b] *of pricked and unpricked Simmaba seedlings on the seedbed at different times of the year.*

Date of sowing	Average total leaf products of seedlings						
	28 days old	49 days old		63 days old		77 days old	
		Pricked	Un-pricked	Pricked	Un-pricked	Pricked	Un-pricked
1935	*Sq. cm.*	*Sq cm.*	*Sq cm.*	*Sq. cm.*	*Sq cm*	*Sq. cm.*	*Sq cm.*
October 1	7.8	31.1	78.9	226.4	390.3	1,049.8	702.5
October 8	6.5	59.4	62.5	298.5	417.9	1,397.5	806.7
October 15	9.9	51.7	80.5	376.5	541.5		
October 22	11.5	80.5	120.8	385.5	898.0		
October 29	8.5	49.6	85.0				
November 5	10.5	57.3	95.3				
November 12	7.0						
Average	8.80	54.93	87.17	321.73	561.93	1,223.65	754.6

[b] Seedlings were pricked when they were 28 days old from the date of sowing.

TABLE 3.—*Development at different ages*[a] *of pricked and unpricked North Carolina Bright Yellow (NCBY) seedlings on the seedbed at different times of the year.*

Date of sowing	Average total leaf products of seedlings						
	28 days old	49 days old		63 days old		77 days old	
		Pricked	Un-pricked	Pricked	Un-pricked	Pricked	Un-pricked
1935	*Sq cm.*	*Sq. cm*	*Sq cm.*	*Sq. cm.*	*Sq cm*	*Sq. cm.*	*Sq. cm.*
October 1	18.2	109.0	184.0	448.0	811.9	1,652.2	1,350.1
October 8	15.6	104.5	167.5	401.2	873.0	1,770.7	1,370.0
October 15	19.4	117.0	192.2	492.0	836.0	----------	----------
October 22	22.1	156.9	282.3	1,127.7	1,309.5	----------	----------
October 29	20.2	165.3	204.0	----------	----------	----------	----------
November 5	19.2	106.4	196.0	----------	----------	----------	----------
November 12	17.3	----------	----------	----------	----------	----------	----------
Average	18.86	126.5	204.33	617.2	957.6	1,711.45	1,360.05

[a] Seedlings were pricked 28 days after sowing.

TABLE 4.—*Development of different ages*[b] *of pricked and unpricked Samsoun Bafra seedlings on the seedbed at different times of the year.*

Date of sowing	Average total leaf products of seedlings						
	28 days old	49 days old		63 days old		77 days old	
		Pricked	Un-pricked	Pricked	Un-pricked	Pricked	Un-pricked
1935	*Sq. cm.*	*Sq cm.*	*Sq. cm.*	*Sq cm.*	*Sq cm.*	*Sq cm.*	*Sq cm.*
October 1	12.2	82.6	105.7	754.2	793.4	1,787.0	1,588.0
October 8	11.5	85.0	101.0	789.4	872.4	1,851.1	1,701.5
October 15	13.0	95.7	109.0	845.5	931.0	----------	----------
October 22	14.2	125.0	295.5	1,007.0	1,131.9	----------	----------
October 29	13.2	90.7	158.0	----------	----------	----------	----------
November 5	12.2	77.6	108.9	----------	----------	----------	----------
November 12	11.9	----------	----------	----------	----------	----------	----------
Average	14.0	97.77	146.35	849.025	932.175	1,819.05	1,544.75

[b] Seedlings were pricked when they were 28 days old from the date of sowing.

TABLE 5.—*Development of different ages of tobacco seedlings at the time of transplanting and percentage of death a week after transplanting.*

Ilagan Sumatra	Size of seedlings at transplanting time at different ages					
	44		51		58	
	Pricked	Unpricked	Pricked	Unpricked	Pricked	Unpricked
1. Average total leaf products of green leaves ... sq. cm.	40.2	85.5	86.5	127.0	202.5	388.1
2. Average measurement of length and width of biggest leaf ... cm. L	4.2	6.0	7.0	10.0	12.1	13.5
W	2.2	3.5	3.5	5.5	7.8	7.8
3. Average height of seedlings ... cm.	(a)	3.0	0.5	5.0	5.0	10.0
4. Average circumference of stem ... cm.	(a)	0.9	(a)	1.0	1.0	1.2
5. Per cent death-effect of transplanting ...	24	10	18	4	8	0

Ilagan Sumatra	Size of seedlings at transplanting time at different ages							
	65		72		79		86	
	Pricked	Unpricked	Pricked	Unpricked	Pricked	Unpricked	Pricked	Unpricked
1. Average total leaf products of green leaves ... sq. cm.	332.5	560.5	822.5	807.1	1,315.1	1,103	1,637.0	1,286.3
2. Average measurement of length and width of biggest leaf ... cm.	L 13.5	14.0	18.0	18.5	24.0	20.0	25.0	21.5
	W 7.5	8.0	9.0	9.0	14.0	9.5	16.0	12.5
3. Average height of seedlings ... cm.	12.0	12.0	14.0	14.5	30.0	26.0	40.0	32.0
4. Average circumference of stem ... cm.	2.2	1.3	3.0	1.3	3.4	1.8	4.2	2.0
5. Per cent death-effect of transplanting ...	0	0	0	6	20	14	24	26

[a] In rosette form.

TABLE 6.—*Development of different ages of tobacco seedlings at the time of transplanting and percentage of death a week after transplanting.*

Simmaba	Age of seedlings in days at transplanting time					
	44		51		58	
	Pricked	Unpricked	Pricked	Unpricked	Pricked	Unpricked
1. Average total leaf products of green leaves ... sq. cm.	44.0	65.6	59.4	91.2	192.2	325.7
2. Average measurement of length and width of biggest leaf ... cm.	*L* 4.8	5.5	6.5	7.5	9.5	10.5
	W 2.5	3.5	3.5	4.5	5.0	6.0
3. Average height of stem ... cm.	([a])	3.5	([a])	5.0	3.0	12.0
4. Average circumference of stem ... cm.	([a])	1.2	([a])	1.5	1.6	1.8
5. Per cent death-effect of transplanting	22	14	20	6	12	2

Simmaba	Age of seedlings in days at transplanting time							
	65		72		79		86	
	Pricked	Unpricked	Pricked	Unpricked	Pricked	Unpricked	Pricked	Unpricked
1. Average total leaf products of green leaves ... sq. cm.	332.5	563.0	787.5	661.0	1,235.0	759.0	1,655.5	853.5
2. Average measurement of length and width of biggest leaf ... cm.	L 12.5	15.0	23.0	22.0	26.0	25.0	28.0	27.0
	W 6.0	7.2	11.0	10.0	10.0	11.0	13.0	11.5
3. Average height of stem ... cm.	10.0	14.0	17.5	17.0	25.0	18.0	30.0	20.0
4. Average circumference of stem ... cm.	2.4	2.0	2.6	2.1	3.0	2.2	3.3	2.3
5. Per cent death-effect of transplanting	0	2	8	10	14	10	18	22

[a] In rosette form.

TABLE 7.—*Development of different ages of tobacco seedlings at the time of transplanting and percentage of death a week after transplanting.*

North Carolina Bright Yellow	Age of seedlings in days at transplanting time					
	44		51		58	
	Pricked	Unpricked	Pricked	Unpricked	Pricked	Unpricked
1. Average total leaf products of green leaves ... sq. cm	98.1	154.8	134.5	216.4	379.5	590.9
2. Average measurement of length and width of biggest leaf ... cm: *L*	6.0	9.0	9.0	12.8	14.2	15.9
W	4.0	5.2	4.5	5.0	6.0	7.6
3. Average height of seedlings ... cm	([a])	4.0	([a])	5.5	3.0	12.5
4. Average circumference of stem ... cm	([a])	1.3	([a])	1.6	1.9	2.3
5. Per cent death-effect of transplanting	12	6	10	2	4	2

North Carolina Bright Yellow	Age of seedlings in days at transplanting time							
	65		72		79		86	
	Pricked	Unpricked	Pricked	Unpricked	Pricked	Unpricked	Pricked	Unpricked
1. Average total leaf products of green leaves ... sq. cm	631.5	967.5	1,177.5	1,168.5	1,723.4	1,369.3	2 081.2	1,829.3
2. Average measurement of length and width of biggest leaf ... cm: L	17.0	18.0	24.0	22.5	27.0	25.5	29.0	27.5
W	9.0	9.0	12.0	11.0	12.5	11.5	13.0	12.0
3. Average height of seedings ... cm	9.5	13.5	18.5	17.5	20.5	19.0	24.5	21.0
4. Average circumference of stem ... cm	2.1	2.5	3.3	2.3	3.5	2.5	3.5	2.5
5. Per cent death-effect of transplanting	0	2	8	4	10	12	10	14

[a] In rosette form.

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TABLE 8.—*Development of different ages of tobacco seedlings at the time of transplanting and percentage of death a week after transplanting.*

Samsoun Bafra	Age of seedlings in days at transplanting time					
	44		51		58	
	Pricked	Unpricked	Pricked	Unpricked	Pricked	Unpricked
1. Average total leaf products of green leaves ....sq. cm.	77.1	113.4	105.8	157.5	477.0	549.5
2. Average measurement of length and width of biggest leaf ....cm. L	4.0	8.0	7.5	11.0	13.0	15.0
W	3.7	5.0	5.0	6.5	9.5	8.5
3. Average height of seedlings........cm.	(a)	2.5	(a)	6.0	4.0	14.0
4. Average circumference of stem........cm.	(a)	1.0	(a)	1.3	1.9	1.8
5. Per cent death-effect of transplanting........	12	6	10	2	4	2

Samsoun Bafra	Age of seedlings in days at transplanting time							
	65		72		79		86	
	Pricked	Unpricked	Pricked	Unpricked	Pricked	Unpricked	Pricked	Unpricked
1. Average total leaf products of green leaves........sq. cm.	855.0	942.9	1,427.3	1,298.5	1,903.3	1,648.5	2,358.3	1,962.5
2. Average measurement of length and width of biggest leaf........cm. L	17.0	18.0	18.0	19.0	20.0	19.5	21.0	20.5
W	11.0	11.0	11.0	11.0	12.0	11.0	12.5	11.0
3. Average height of seedlings........cm.	12	17	17.0	20	29	27	39	36
4. Average circumference of stem........cm.	2.0	2.0	2.5	2.4	2.5	2.3	2.7	2.6
5. Per cent death-effect of transplanting........	0	2	2	4	10	12	10	14

[a] In rosette form.

TABLE 9.—*Growth rate of tobacco plants 32 days after transplanting on the field.*

Variety and criteria considered		Age of seedlings in days at transplanting time					
		44		51		58	
		Pricked	Unpricked	Pricked	Unpricked	Pricked	Unpricked
ILAGAN SUMATRA							
1. Average number of leaves [a]		6.5	6.5	7.0	7.5	8.0	9.5
2. Average measurement of length and width of largest leaf ... cm.	L	19.5	20.5	20.0	23.5	24.0	27.5
	W	11.7	12.7	12.5	15.0	15.5	17.2
3. Average leaf product of green leaves ... sq. cm.		171.2	524.5	801.8	1,359.9	2,067.9	3,210.2
4. Growth rate increase (leaf product) ... per cent.		325	513	827	971	921	727
SIMMABA							
1. Average number of leaves [a]		7.5	7.5	8.0	8.5	9.0	10.0
2. Average measurement of length and width of largest leaf ... cm.	L	26.5	30.0	30.5	31.0	34.5	38.5
	W	12.0	15.0	14.0	17.0	18.5	22.5
3. Average leaf product of green leaves ... sq. cm.		170.2	352.1	534.4	904.8	1,920.2	3,262.2
4. Growth rate increase (leaf product) ... per cent.		287	436	799	892	899	901

TABLE 9.—*Rate of tobacco plants, etc.*—Continued.

Variety and criteria considered	Age of seedlings in days at transplanting time							
	65		72		79		86	
	Pricked	Unpricked	Pricked	Unpricked	Pricked	Unpricked	Pricked	Unpricked
ILAGAN SUMATRA								
1. Average number of leaves [a]	8.0	10.0	10.5	9.5	13.0	10.5	14.5	11.0
2. Average measurement of length and width of largest leaf ... cm	27.5	31.5	30.7	28.5	31.2	29.5	27.2	28.0
	18.0	21.2	18.5	17.5	20.7	19.7	15.7	17.2
3. Average leaf product of green leaves ... sq. cm	2,595.4	3,525.2	3 345.2	2,989.8	3,914.3	2,755.8	3,505.0	1,633.5
4. Growth rate increase (leaf product) ... per cent	681	529	307	270	198	149	114	27
SIMMABA								
1. Average number of leaves [a]	11.5	11.0	11.5	10.0	10.5	9.5	10.0	9.5
2. Average measurement of length and width of largest leaf ... cm	43.5	45.5	43.0	37.0	39.5	37.0	37.0	28.5
	23.5	22.5	24.0	16.0	20.5	17.5	18.5	12.0
3. Average leaf product of green leaves ... sq. cm	3,125.6	5,147.9	4,931.8	4,020.4	5,590.4	2,810.0	4,991.2	2,034.1
4. Growth rate increase (leaf product) ... per cent	840	814	526	508	352	270	201	138

[a] Number of leaves includes dry, yellow, and green leaves.

TABLE 10.—*Average total leaf product (green leaves) of one plant at priming period.*

Age of seedlings at transplanting	Ilagan Sumatra		Simmaba	
	Pricked	Unpricked	Pricked	Unpricked
Days	*Sq. cm.*	*Sq. cm.*	*Sq. cm.*	*Sq. cm.*
44	9,293.7	11,342.8	9,089.8	12,499.3
51	13,217.5	14,213.2	16,639.5	16,985.9
58	14,200.4	14,011.2	17,832.5	17,794.5
65	12,950.1	11,024.2	17,432.4	16,998.5
72	11,375.1	10,207.8	15,309.7	14,942.4
79	10,952.4	9,093.7	12,925.6	10,942.0
86	8,954.2	6,729.3	10,717.9	8,438.4

TABLE 11.—*Computed yield per hectare based upon harvest data of 25 tobacco plants.*

Variety and distance of planting	Age of seedling	Pricked: Fresh weight	Pricked: Dry weight	Pricked: Water content [a]	Pricked: Yield per hectare	Unpricked: Fresh weight	Unpricked: Dry weight	Unpricked: Water content [a]	Unpricked: Yield per hectare
	Days	*Grams*	*Grams*	*Per cent*	*Quintal*	*Grams*	*Grams*	*Per cent*	*Quintal*
ILAGAN SUMATRA (Wrapper type) 80 × 50 cm.	44	6,501	910	86	18.2	7,854	1,021	87	20.4
	51	7,354	1,016	87	20.3	9,286	1,301	86	26.0
	58	8,500	1,275	85	25.5	9,143	1,280	86	25.6
	65	8,257	1,156	86	23.1	8,462	1,100	87	22.0
	72	7,578	1,071	86	21.4	6,614	926	86	18.5
	79	6,106	916	85	18.3	5,471	766	86	15.3
	86	5,808	755	87	15.1	4,769	620	87	12.4
SIMMABA (Cigar-filler type) 80 × 70 cm.	44	9,433	1,415	85	20.2	12,664	1,773	86	25.2
	51	12,659	1,772	86	25.3	14,250	2,137	85	30.5
	58	17,669	2,297	87	32.8	16,300	2,282	86	32.0
	65	16,916	2,199	87	31.4	14,366	2,155	85	30.7
	72	14,360	2,154	85	30.7	14,164	1,983	86	28.3
	79	12,657	1,772	86	25.3	11,107	1,555	86	22.2
	86	8,850	1,416	84	20.2	7,140	1,071	85	15.3
NORTH CAROLINA BRIGHT YELLOW (Virginia cigarette-filler type) 80 × 70 cm.	44	7,914	1,197	85	17.1	9,331	1,401	84	20.0
	51	10,915	1,429	87	20.4	14,007	1,821	87	26.0
	58	12,657	1,772	86	25.3	12,557	1,758	86	25.1
	65	11,020	1,653	85	23.6	10.833	1,625	85	23.2
	72	10,877	1,414	87	20.2	10,078	1,417	86	20.2
	79	8,540	1,281	85	18.3	7,053	1,058	85	15.1
	86	7,550	1,057	86	15.1	6,002	840	86	12.0

SAMSOUN BAFRA (Turkish cigarette-filler type)									
80×50 cm.	44	4,400	660	85	13.2	5,401	756	86	15.1
	51	6,654	865	87	17.3	7,307	950	87	19.0
	58	6,457	904	86	18.1	6,160	924	85	18.5
	65	5,700	761	87	15.2	4,329	606	86	12.1
	72	4,386	614	86	12.3	3,726	559	85	10.2
	79	3,566	535	85	10.7	3,277	426	87	8.5
	86	3,250	455	86	9.1	2,600	364	86	7.3

[a] Water content based on fresh weight of leaves.

[b] 1 Quintal = 50 kg. (gross weight) instead of 46 kg. (net weight).

DISCUSSION OF RESULTS

Growth rate of pricked and unpricked seedlings on the seed-bed compared.—When the root system of a tobacco seedling was disturbed during its early period of growth or seedling stage, the growth rate of the leaves during that period was greatly retarded (Tables 1, 2, 3, and 4). The total leaf products of the seedlings developed from seeds of Ilagan Sumatra sown on October 1 and 8, 1935 (Table 1) and pricked at the age of 28 days, compared to unpricked seedlings of the same age, three weeks later, were 34.6 and 31.1 per cent smaller, respectively. And, when compared again two weeks after, still the pricked plants were smaller. This behavior of growth development is not only exhibited by the October planting but also by the November planting. This is also true in the other three varieties of tobacco studied (Tables 2, 3, and 4). But after the pricked seedling had reëstablished its root system, the growth rate of the seedling was greatly accelerated. Seven weeks after pricking, the total leaf products of pricked seedlings were bigger than the leaf products of unpricked plants (Tables 1, 2, 3, and 4). The retardation of the rate of growth of the pricked seedlings following pricking operation (around 5 weeks) is due to the fact that pricking is a violent operation, because the young roots with their root hairs are torn away. In a previous paper (Peralta and Paguirigan 1936) the following observation was made:

> In spite of the extreme precaution resorted to during the time of pricking, the tip of the primary root was broken in the course of lifting.

The root tips and root hairs are the most important parts of the root system for absorption. Unless more roots are produced with a short period of time, after pricking, the normal rate of absorption of pricked seedlings is impaired. Under this state of condition, growth rate is retarded to a certain extent.

Tobacco (Peralta and Paguirigan 1936) possesses the power of producing branch roots rapidly, shortly after pricking. In studies on the root development of tobacco plants the following were found:

> * * * The number of secondary roots increased from 7 to 11 and also branch roots of the second order appeared. This rapid growth happened within a period of 5 days. The length of the roots of the secondary roots ranged from 0.5 to 4.2 cm with a total length of 17.5 cm. Some of the roots ran rather horizontally outward, others obliquely downward, all into territory unoccupied by the primary root ramifying in a volume of soil 4 cm in diameter and 3.7 cm deep."

In spite of the inherent property of tobacco seedlings to produce roots rapidly after pricking, still the retarding effect of pricking upon the growth of tobacco seedlings was so great that pricked seedlings 28 days old required at least about seven weeks to fully overcome rapid uninterrupted growth of the unpricked plant. (Tables 1, 2, 3, and 4). But why did the rate of growth of unpricked seedlings lag behind after a period of 77 days on the seedbed? This behavior of leaf growth of the unpricked plants is explained to be due to two causes, namely, competition among the leaves for sunlight on the one hand, and competition among the roots for water and nutrient on the other.

The unpricked seedlings were sown at the rate of 0.10 gram per square meter. With this rate of seedling, 236 plants developed and spaced on the average of 6.5 cm apart. The pricked seedlings were set on the seedbed at 10 cm each way. Tobacco seedling, 64 days old was described by Peralta and Paguirigan (1936) as follows:

> The tip of the seventh leaf had appeared * * * with a leaf spread of 9 cm. The number of secondary roots increased from 12 to 16 and tertiary roots were abundantly produced ranging from a few millimeters to 1.5 cm in length. The bulk of the absorbing surface ramified in the first 4-centimeter layer of soil occupying a volume of soil 8.5 cm in diameter and 7.5 cm in depth. The total length of the root system averages 117.9 cm.

In the light of the above cited finding, it is obvious that during a period of 14 days, between the ages of 63 and 77 days (Tables 1, 2, 3, and 4), the leaves of the unpricked seedlings were overlapping each other. According to Weaver, 1929, shaded leaves can not do photosynthetic work. Therefore, there was a reduction in the rate of photosynthesis of the unpricked seedlings because only the unshaded leaves can do photosynthetic work. At the same time there was competition among the roots for water and nutrient. The roots of one plant after attaining the age of 63 days were already encroaching upon the domain of another plant for water and nutrient. This state of condition of the unpricked seedlings when the age of 64 days was reached resulted in a diminution in the growth rate of the tobacco plant. On the other hand, as the pricked seedlings were spaced 10 cm apart, the leaves at this period did not overlap each other. Most of the leaves, if not all, were able to do photosynthetic work. Likewise the roots were not yet competing for water and nutrient. These decided advantages of the pricked seedlings towards the later period of growth development made

it possible for the pricked plants to overcome the rapid growth rate of the unpricked seedlings upon reaching at least the age of 77 days.

Best size and age of planting material.—The results presented in Tables 5, 6, 7, and 8 and the graphs in Figure 1 conclusively show that the size of planting material is a very important factor to consider in the culture of tobacco plants. The seedlings transplanted young with leaves 4.2 cm long and 2.2 cm wide were not good planting materials. A very high percentage of death was observed a week after they were transplanted. Likewise, tobacco seedlings that were big and old and had developed leaves with a total leaf product (green leaves) of not less than 1,000 sq. cm were also poor planting materials (Table 5). Seedlings of this size were at least 70 to 80 days old.

Further examination of Tables 5, 6, 7, and 8 show that in general, the best planting materials (using per cent death-effect of transplanting as criterion) were seedlings, the lengths of the biggest leaf of which ranged from 10 to 18 cm. This size of planting material was obtained from seedlings with ages ranging from 51 to 65 days. The size of the leaves is very essential to consider especially when pruning of leaves is not practised during the time of transplanting, as done in many crop plants, in order to balance the destroyed roots during the process of transplanting. It is of interest to note, however, that the length of the biggest leaf of pricked seedlings 51 days old was less than 10 cm. Whereas, the lengths of the biggest leaf of unprickled seedlings were 10 cm or longer. The size was attained by pricked plants of the early maturing varieties, like Ilagan Sumatra, Samsoun Bafra, and North Carolina Bright Yellow, within 58 days and by pricked plants of the late maturing variety, like Simmaba within 65 days. There was, therefore, no advantage gained (as regards time) of pricking seedlings. On the other hand, it was an unnecessary operation in the growing of tobacco, especially when the culture is carried on extensively.

Effect of age and size of planting materials upon the growth rate and successive developments of tobacco plants.—Upon examination of the figures presented in Tables 5 and 9 and the graphs shown in Figure 2, the following facts were evident, thirty-two days after transplanting on the field: For the early maturing variety like Ilagan Sumatra, the most rapid growth rate

observed on the field was that of the unpricked planting materials, 51 days old, and, that of the pricked plants, 58-day-old seedlings. The average leaf product of the former increased from 127.0 sq. cm to 1359.9, and that of the latter from 202.5 sq. cm. to 2,067.9 (Figure 2). The percentage of growth in-

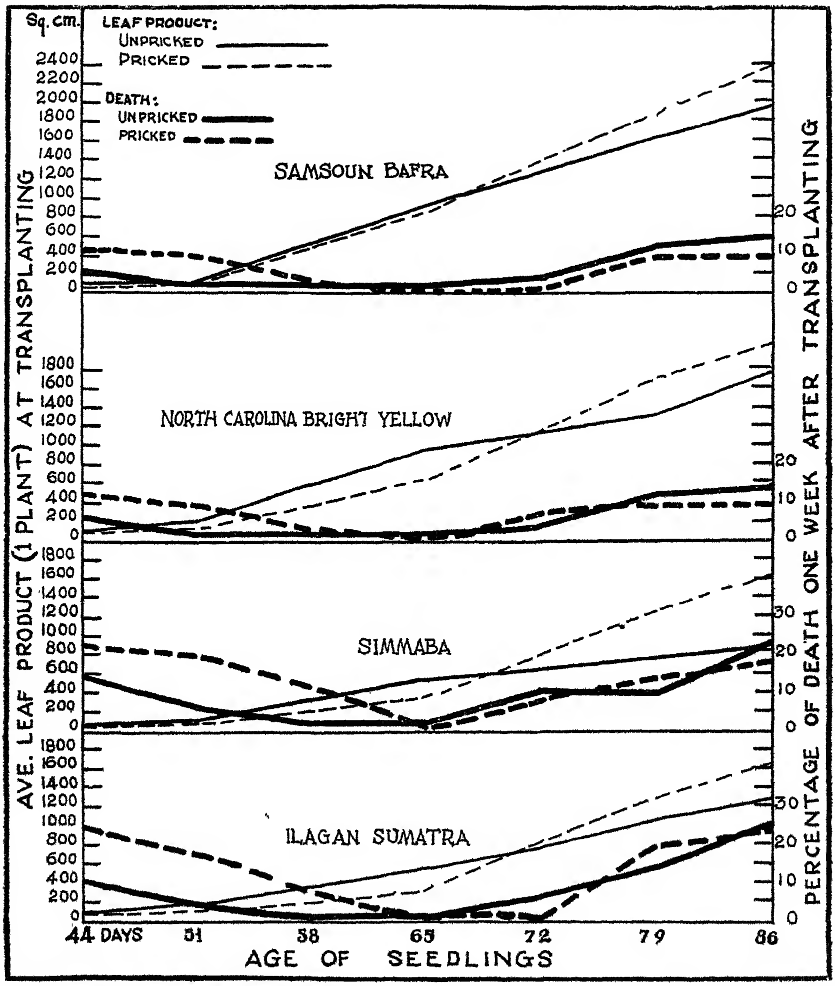

FIG. 1. Graphs showing effects of age and size of planting materials upon the ability of transplanted seedlings on the field to survive one week after transplanting.

crease was 971 for the unpricked and 921 for the pricked seedlings. For the late maturing variety like Simmaba, the 58-day-old pricked and unpricked planting materials showed the most rapid rate of growth.

The biggest developed plants, thirty-two days after the transplanting of the early and late unpricked maturing varieties, were the seedlings transplanted at the age of 65 days. The average total leaf product of the early maturing variety was 3,525.2 sq. cm and that of the late maturing variety was 5,147.9 sq. cm. The biggest plants of the transplanted pricked planting mate-

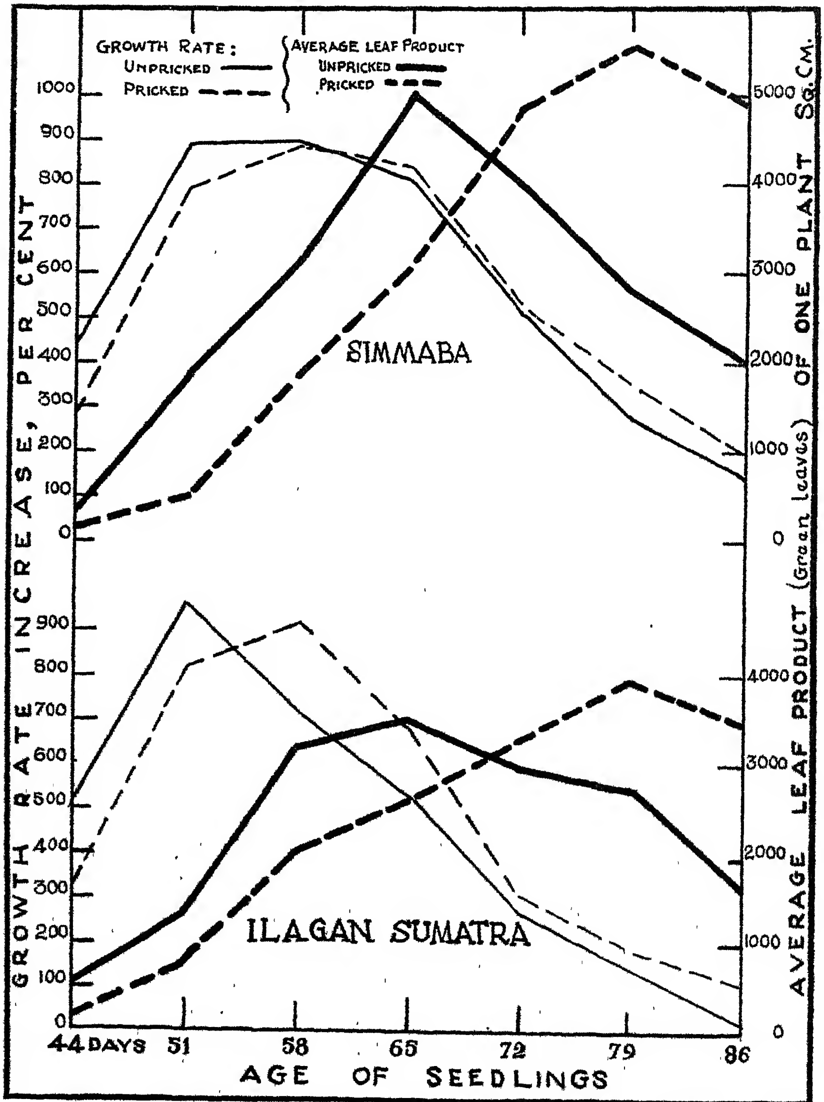

FIG. 2. Graphs showing effect of age of planting materials upon growth rate and stature of tobacco plants during the first 32 days on the field after transplanting.

rials after the same length of time were the 79-day-old seedlings (Figure 2).

When the tobacco plants reached full maturity (at the time of first priming), the most developed plants of the early maturing variety were the unpricked seedlings transplanted at the age of 51 days. The next biggest plants were the pricked seedlings transplanted when they were 58 days old. The biggest plants of the late maturing variety, like Simmaba, were those transplanted pricked and unpricked seedlings at the age of 58 days. Small plants were developed from seedlings transplanted at the ages of 44, 79, and 86 days (Figure 3).

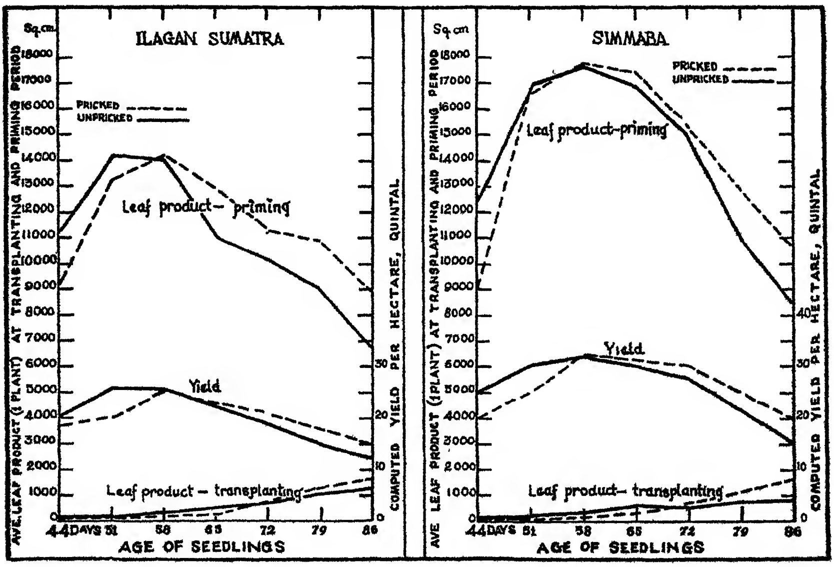

FIG. 3. Graphs showing effect of age and size of planting materials upon the final development and yield of tobacco plants.

In the present study under discussion, seedlings 44 days old from the date of sowing were transplanted. It was found out that the rate of growth was much slower than the growth rate of the 58-day-old seedlings. Of the early maturing varieties, like Ilagan Sumatra, seedlings transplanted less than 51 days old developed into small plants. Likewise, seedlings of the late maturing variety, like Simmaba less than 58 days old, also developed small plants.

Effect of age and size of planting material upon yield.—The age of planting material does not only modify the rate of growth of the plant, but also affects the yield. Table 11 shows

that when tobacco seedlings were transplanted at ages between 51 and 65 days, the highest yield possible was obtained. This fact was found true in all of the four varieties of tobacco tried.

Unpricked seedlings transplanted at the age of 79 days or older yielded less than seedlings transplanted at the age of 44 days. But pricked seedlings 79 days old or older produced a heavier yield than unpricked seedlings of the same age. On the other hand, unpricked 44 day-old-seedlings gave yield greater than pricked plants when transplanted at the age of 44 days.

Of the early maturing varieties like Ilagan Sumatra, North Carolina Bright Yellow, and Samsoun Bafra, the best yield was obtained from unpricked seedlings transplanted at the age of 51 days. But when the seedlings were pricked, the highest yield was obtained from seedlings transplanted when they were 58 days old. Comparing the two highest yields obtained from the unpricked and pricked seedlings, the produce from the transplanted unpricked 51-day-old seedlings were heavier (Table 11). Under this condition the results obtained corroborate the findings of Weaver and Clemente (1929), who state:

> Experiments have clearly shown that the general effect of transplanting is to retard growth, delay fruiting, and reduce yield. The degree of retardation varies with the kind of plant, its age, and the conditions of transplanting.

From the late maturing variety like Simmaba, the best yield was obtained from unpricked and pricked seedlings transplanted at ages between 58 and 65 days. This shows that a late maturing variety of tobacco takes longer time to develop seedlings to the best size of planting material on the seedbed than seedlings of early maturing ones, inasmuch as the latter only took 51 days. This difference of time is an important item to consider in the raising of tobacco. The crowding of time during transplanting period on the field can be avoided.

SUMMARY

1. The three types of tobacco, namely, the cigar-wrapper, the cigar-filler, and the cigarette-filler were grown in Los Baños Economic Garden, Los Baños, Laguna during the years 1935 and 1936.

2. Different ages of pricked and unpricked seedlings ranging from 44 to 86 days old from the date of sowing were used as planting materials. The pricked seedlings were spaced 10 cm

apart on the seedbed, and the unpricked seedlings were spaced, on the average, 6.5 cm apart on the seedbed. The rate of sowing was 0.10 gm per square meter.

3. A very high percentage of recovery was observed by transplanting on the field tobacco seedlings with leaves, the length of the biggest leaf of which was not less than 10 and more than 18 cm. To attain the minimum size, best for transplanting, the seedlings took 51 days to develop, when unpricked and 58 when seedlings.

4. The best size of planting materials was developed by unpricked seedlings within 51 days (for the early maturity varieties). Pricked seedlings at this age (51 days old) were found still below the average best size of planting materials. There was no advantage gained as regards time of pricking seedlings.

5. Under normal conditions, seeds of late maturing varieties, like Simmaba, required at least 58 days' time on the seedbed before the best size of planting materials could be developed.

6. Planting materials as old as 44 days or as old as 79 days did not develop to a big plant upon reaching maturity. The best stands of tobacco plants were obtained from seedlings transplanted at ages of between 51 and 65 days.

7. Of the early maturing varieties of tobacco, like Ilagan Sumatra, North Carolina Bright Yellow, and Samsoun Bafra, unpricked seedlings transplanted at the age of 51 days produced the heaviest yield. The pricked 58-day-old planting materials produced the second heaviest yield.

8. Of the pricked and unpricked seedlings of the late maturing variety, like Simmaba, the 58-day-old produced the highest yield. But seedlings of Simmaba variety transplanted at the age of 65 days produced yield higher than that of either the seedlings transplanted at the age of 45 days, or the seedlings transplanted at the age of 51 days.

9. When transplanting on the field was delayed (as late as 72 days), pricked planting materials produced yield better than that of unpricked plants.

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ILLUSTRATIONS

TEXT FIGURES

AROMATIC CIGARETTE LEAF TOBACCO CULTURE IN THE PHILIPPINES

(Farmers' Circular 16)

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THREE PLATES

Choice of varieties (Plate 1, figs. 1 and 2; Plate 2).—In the order of their yields the varieties *North Carolina Bright Yellow, Adcock,* and *Orinoco* are recommended for the Virginia type and *Samsoun Bafra* for the Turkish type. Of the Virginia type, the *North Carolina Bright Yellow* has the brightest yellow leaves.

Soil requirements.—Cigarette tobacco has been successfully grown in soil ranging from heavy clay loam to sandy loam of normal fertility. The *Samsoun Bafra,* however, should never be grown in rich land.

Climatic requirements.—The best quality of cigarette leaf tobacco has been produced by sun-curing in regions with well-defined dry and wet seasons, like the Ilocos provinces and Central Luzon. In regions like the Cagayan Valley, where the dry period lasts from one to three months only, cigarette leaf tobacco has also been successfully produced with the use of the rather expensive flue-curing barn.

The optimum seasonal periods of field operations for sun-cured cigarette tobacco are as follows:

Sowing of seeds	September 15 to October 15
Transplanting	November 1 to December 15
First harvest (priming)	January to February
No. of days required to cure leaves under the sun	12–24
No. of harvests	4–15
Intervals between harvests	10–12 days
Last harvest (till beginning of rainy season)	May

Location and Preparation of seedbeds.—That portion of the field near a good water supply where rain water does not stagnate should be selected for the seedbeds.

In the early part of September, the land is plowed and harrowed until the soil becomes thoroughly pulverized. Then the plot is divided into beds, 1.2 meters wide and 10 meters long. The beds should be separated from each other by paths dug out to a depth of about 10 cm, and the soil should be placed over the beds, thus raising them. The low paths will serve as drainage canals. Each seedbed is provided with portable abacá cloth, nipa, or cogon sheds to protect the seedlings from the rain and intense heat of the sun. The east side of the shed should be raised to about a meter high and the west side to about 75 cm. from the ground, in order that the seedlings may receive the mellow heat of the morning sun but not the strong afternoon sun.

The final preparation of the seedbeds consists in working the soil with hand tools until the particles become pulverized.

Sowing of seed.—Before sowing the seed it is always advisable to test the percentage of germination. The simplest method is to place 100 seeds between two pieces of blotting paper on a clay plate with a cover to fit, and then keep the blotting papers moist for one week, when the percentage of germination can be determined by counting the number of seeds which have germinated. Five or six grams of seeds with a percentage of germination ranging from 70 to 100 per cent will be a sufficient quantity to sow in one bed that measures 1.2 by 10 meters. Before the seed is sown, the beds should be sterilized by pouring boiling water over them. The uniform distribution of seed in the bed is insured by mixing it with about 10 parts of wood ash or fine sand before sowing.

Each seedbed of the size mentioned above will produce not less than 1,000 good seedlings. In this system about 20 beds will be required for every hectare. It is always practical to sow extra beds after two weeks as a precaution against adverse conditions.

When there are many red ants in the seedbeds there is always danger of the seeds being carried away by them. To prevent this, it is a good plan to scatter corn meal made into a mash with sugar along the borders of every seedbed. The bait will keep the ants away from the seeds.

It is a general practice among farmers to wrap the tobacco seeds in a piece of cloth and soak them in water for about 48

hours before sowing them in the seedbeds in order to insure germination. Incidentally, ants do not carry the seeds away once they have germinated.

Care of Seedlings.—The soil in the seedbeds should be kept moist all the time. Weeds of any kind should be pulled out as they appear. If the seedlings are attacked by damping-off diseases, all the infected ones including the few healthy ones around the infected area should be removed together with the soil. Treating the infected area with 5 per cent formaline solution will minimize further infection.

Crowded areas in the seedbeds should be thinned so that the remaining seedlings should be about 4 cm apart.

About two weeks before transplanting, the sheds of the beds are removed to expose the seedlings to the sun to make them strong.

Preparation of the field.—If thick grass is growing in the field, it must be cut down and burned. The land should be plowed and harrowed at least two times or until the soil becomes well pulverized. One or two days before planting, furrows are to be made in the field 80 cm apart. The native plow is appropriate for this purpose.

Planting.—The seedlings are ready for planting at the age of about six weeks. Before pulling them up the beds should be watered thoroughly to make the soil soft, thereby minimizing the breakage of the root systems of the plants. Only healthy and vigorous seedlings are to be selected for planting. With a trowel, holes of sufficient depth are made along the furrows, 70 cm apart for the Virginia varieties and 50 cm for the Turkish varieties. In setting the seedlings in the holes one must be careful not to bend the roots as this arrests normal development. The earth around the base of the plants should be pressed down gently with the fingers in order to make the plants stand firm in the soil. A week later all dead seedlings should be replaced.

Cultivation.—As soon as the plants are well established in the soil, the first cultivation is done by passing the plow twice between the rows. Cultivation is repeated at regular intervals of two weeks until the plants are big enough.

Control of pests and diseases.—Of all the insect enemies of the tobacco plant, the cutworms are the most destructive. Control is effected by dusting the plants with calcium arsenate. It is prepared by mixing one part commercial calcium arsenate pow-

der with 16 parts of sterilized road dust. A bamboo tube with a node at one end and the other end covered with cheesecloth or fine mesh wire will make a cheap and practical duster. The dust is applied to each individual plant by shaking the tube to make the powder pass through the cheesecloth or wire until the top leaves are sufficiently covered with a thin layer of the mixture. Occasional hand picking insures the perfect control of the worms.

The safest guide to follow in controlling fungus diseases is to practice sanitation even to the extent of pulling up all the plants showing a diseased condition, especially those attacked by mosaic and wilt diseases. It is better to destroy a few plants rather than let the disease spread in the field.

Topping.—Topping should not be done, as a rule, unless the plants are extremely under-developed, as this tends to produce leaves that are too coarse. In cigarette tobacco the aim is to produce leaves with a medium body, so that if topping is practised at all, only the flower buds are pinched off as they appear.

Seed selection.—The seed for subsequent planting should be taken only from healthy and vigorous plants. The plantation should be gone over thoroughly when the crop is about to flower and the most ideal and vigorous plants are selected. To keep the seeds pure, the entire flower head of each individual plant should be covered with Manila paper bags before the flowers open and until the seed pods are fully developed. When the capsules are mature, they are cut off from the stem of the mother plant, and are hung inside the shed for thorough drying. The capsules are then hulled, and the seeds are stored in air-tight containers. The seeds, if stored properly, will remain viable for at least two years.

Harvesting.—Some of the leaves begin to mature in about 6 to 8 weeks from the time of transplanting. The leaves can be harvested by priming or picking them one by one as they become mature. Immature as well as over-ripe leaves should not be harvested. Change of color from dark green to light green is a good index of maturity.

Stringing and poling.—As soon as the leaves are gathered from the field, they should immediately be taken into the shed and then sorted according to size and soundness. Broken and worm-eaten leaves should be further separated.

Stringing is done by passing the needle with twine or string through the petiole of the leaves. About 100 leaves are ar-

ranged, preferably face-to-face and back-to-back and about 1 cm apart on the string. Each end of the string is attached to a pole of practically the same length as the string and about 2 to 4 cm in diameter.

Native sticks can also be used, provided the leaves are stuck just as described.

Sun-curing.—The poled or stacked leaves are to be hung on racks outside in the sun until they become thoroughly dry. But portable covers should be ready in case of rain or dew.

Flue-curing.—In regions like the Cagayan Valley, where sun-curing is not practicable owing to uncertain weather conditions or to the short dry period, flue-curing has to be resorted to. This method of curing necessitates the construction of a hermetically tight barn, heated gradually by a system of flues to a maximum of 66° C.

Preparation of product for the market.—When the leaves are thoroughly cured, they are removed from the poles or sticks and placed in bundles of 25 (more or less) each. The number of leaves in each bundle need not be exact inasmuch as they are sold by weight. A leaf should be used for tying a bundle, because this is convenient, not only for the manufacturer who must cut the whole hand, but also for the grower who is thus saved the cost of the tying material.

The bundles or hands should then be packed in receptacles, and suitable weights should be placed over the piles, not only to prevent the penetration of harmful nicotine, but also at the same time, to conserve the much-desired volatile aroma of the leaves.

ILLUSTRATIONS

PLATE 1

FIG. 1. An ideal plant of the North Carolina Bright Yellow, one of the best variety adaptable under Philippine condition for the production of aromatic cigarette leaf tobacco.

2. An ideal plant of the Samsoun Bafra variety, a Turkish type acclimatized for the production of aromatic leaves used for blending in the manufacture of American-style cigarette.

PLATE 2

FIG. 1. A partial view of Virginia tobacco plantation of the Cresana variety in the hacienda of Samson Hermanos Co., Inc.

2. Another view of a Virginia tobacco plantation of the Adcock variety in the hacienda of Samson Hermanos Co., Inc.

PLATE 3

FIG. 1. A modern flue-curing barn for the curing of Virginia and Turkish tobacco, Central Experiment Station, Bureau of Plant Industry, Manila.

2. Interior view of a miniature flue-curing barn showing the arrangement of the heating system and the method of hanging the leaves to be cured.

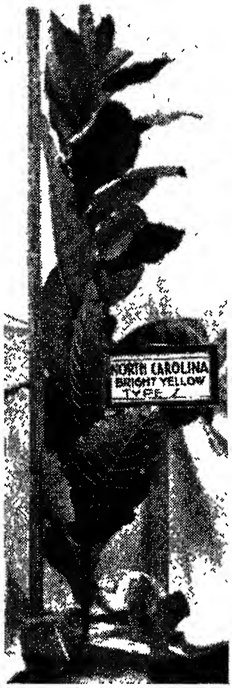

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PLATE 1

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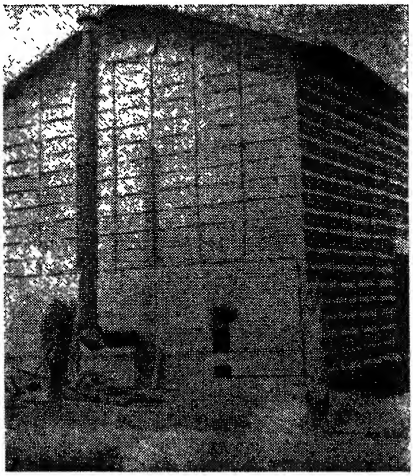
PLATE 2



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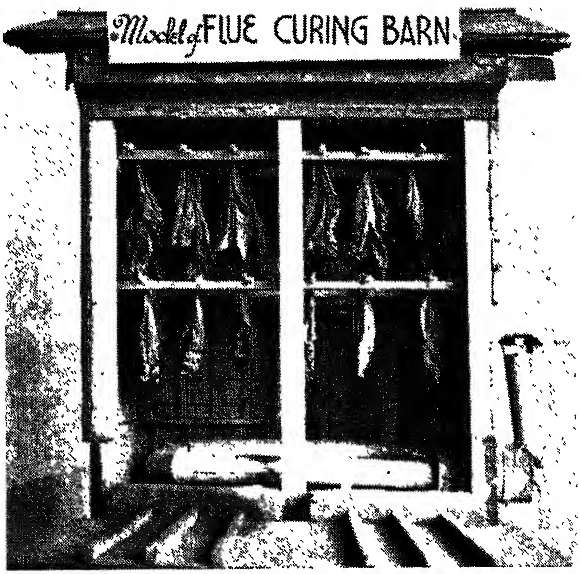

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PLATE 3

THE CULTURE OF COFFEE

(Farmers' Circular 4)

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TWO PLATES

At present the per capita consumption of coffee in the Philippines is very low—0.23 kilo against 5.6 kilos for the United States, 6.9 kilos for Norway, and 7.0 kilos for Sweden, the three greatest coffee-consuming countries of the world. That for Great Britain and Ireland amounts to only about 0.4 kilo a year, but even this small amount is greater than that of the Philippines. Yet, the annual importation of coffee into the Islands amounts to over a million and a half pesos. A revival of the once flourishing coffee industry of the Philippines will greatly reduce this importation or stop it altogether.

COFFEE VARIETIES AND THEIR REQUIREMENTS

Many farmers in this country often commit the mistake of planting coffee varieties in localities not well suited to their growth. It ought to be remembered that a given variety of coffee will only succeed when cultivated at proper altitudes and in a district with proper rainfall. In other places where the environment is not favorable, it may also grow if given extraordinary care, but it cannot be raised profitably on a commercial scale. To avoid unnecessary losses of plants and time, only those varieties which are adapted to our soil and climate should be grown.

The principal types of coffee are the Arabian, the Robusta, and the Liberian.

The Arabian type, which includes the Porto Rican, Padang, Bourbon, Erecta, Columnaris, Maragopipe, San Ramon, Mocha, Kona, and Murta, is found to grow well at lower altitudes with a well-marked short, dry season, but because of the coffee blight, *Hemileia vastatrix*, it should not be planted at altitudes below 800 meters; it thrives best from 2,000 meters up. In the

Mountain Province, the Arabian coffee is attacked by the blight if planted below 1,000 meters elevation. At and above this elevation, the climate is so favorable for the growth of the plant that when kept in good condition it is sufficiently capable of resisting the attack of the blight to yield a profitable crop. Altitude alone, however, does not render this type resistant to blight. Soil and rainfall play important part. It grows best on a rich friable, even rather stiff loamy soil.

The Robusta, with its allied types, Congo, Uganda, Quillou, Canephora, Buckobensis, Sankurensis, and Laurensis, should be planted only in a rich, friable, and well-drained loamy soil and where there is a well-distributed rainfall throughout the year—preferably from 2,000 to 2,500 mm. It is very sensitive to soil acidity. It requires an altitude of from 450 to 750 meters for its best development, although it may be grown from sea level to an elevation of 1,000 meters, and it will not thrive well at altitudes higher than 1,000 meters. It is very susceptible to wind and suffers especially from continuous dry winds. The crop is almost continuous in districts having a well-distributed rainfall. Generally speaking, the coconut and abacá districts of the Philippines are better adapted to the culture of this type if rainfall is to be considered alone.

The Liberian type, which includes the Liberian, Excelsa, Abeocuta, Dybowskii, Dewevrei, and Arnoldiana, requires an elevation of from sea level to 700 meters. But the Liberian variety should not be planted above 350 meters. This type of coffee is drought-resistant, and it succeeds in districts with a pronounced dry season and a rainfall of 1,200 mm. The yields will be greater, however, in places where there is a uniform distribution of rainfall. It thrives even on a heavy clay soil, and from well-drained peaty soils, fairly good crops have been obtained. This group can be grown with or without shade, whereas the Arabian coffee requires shade.

The hybrids, Kawisari B and D, are becoming very popular varieties in Java because of their resistance to the blight and their excellent flavor. They are the natural hybrids of the Liberian and the Arabian coffees. These hybrids can withstand moderate drought, and with heavy rains they grow equally well, that is, they succeed under the same conditions as the Liberian and the Robusta types. The Kawisari B does best at altitudes of about 350 meters, and Kawisari D does best below this elevation.

It should be borne in mind that the rainfall in many parts of the Philippines is rather local. For instance, in the same

province there exists two or more seasons as regards rainfall. Furthermore, the effect of too little and too much rain in the development of coffee plants should be considered. In a marked dry season, the growth is checked, but this is usually followed by an excellent crop. The lack of soil moisture causes crop failures of coffee in spite of the normal courses of pollination. Where coffee is planted in places with marked dry periods coinciding with the blooming period, irrigation would be a good insurance for the regular and normal setting of the coffee berries. On the other hand, if the moisture is excessive; there is a tendency for the coffee plant to produce many leaves and few berries, and if there is too much rain, the flowers will rot and fall without setting fruits, and are also apt to be improperly cross-fertilized. However, coffee needs only a few hours of sunshine for a complete fertilization of its flowers. Heavy rainfall is not injurious to coffee, provided the soil is well drained, and it does not rain during the fertilization of the flowers.

Coffee suffers severely from strong winds, so wind breaks should be provided against the direction of the prevailing winds when natural windbreaks are absent.

The best temperature for coffee is from 60–75° F., and varying altitudes and rainfall are suitable according to the varieties, or types, of coffee.

PLANTING

In the nursery.—The seeds for planting should be carefully selected and only the best, full-grown, and well-shaped beans should be planted, preferably those obtained from mature, vigorous, and productive trees in the plantation. The seeds for planting should never be allowed to pass through the pulping machine, but instead, the husks should be removed by men, women, or children. The beans are then washed in fresh water with sand or ashes to avoid fermentation, then air-dried, and afterwards sown in seedbeds or preserved in moist charcoal, moss, or sand placed in air-tight containers.

The land having rich, loamy soil intended for seedbed and nursery should be well drained. With ordinary rainfall, a light bamboo frame should be erected above the nursery about 2.5 meters high or lower, and covered with split bamboo, cogon, or other grasses or palm leaves to provide half shade. If the rains are so heavy that they are likely to wash out the coffee seeds, they should be sown under a rain-proof shelter. The land should be spaded thoroughly to a depth of about 30 cm and

all stones, roots, and trash removed. From 1 to 1.5 meters is a convenient width for seed and plant beds. The beds should be about 10 cm or so higher than the general level of the ground because of the danger of flooding during heavy rains.

Provided that the seedlings can be properly transplanted to the nursery beds after germination, the coffee seeds may be sown broadcast at the rate of 2,000 to 2,500 seeds to the square meter, but if the transplanting cannot be promptly attended to, it is best to spread the seeds over an area twice as large in order to produce strong plants. The seeds should be covered with not more than one cm of earth, and then watered thoroughly. Unless the rains provide sufficient moisture, the seedbed should be well-watered from time to time whenever the soil appears dry. Frequent sprinkling, but not enough for the water to penetrate more than a few mm below the surface of the soil, is harmful rather than beneficial both in the seedbed and in the nursery, for this encourages a shallow root system.

As soon as the first pair of leaves are fully expanded, the seedlings should be transplanted to the nursery beds, which should be prepared like the seedbeds. If the land is poor, it is well to spade in a liberal quantity of well-decayed manure or compost. The plants should be taken up carefully, the injured tap roots nipped off before transplanting with the aid of a pointed stick or small dibber, spacing them from 15 to 20 cm apart each way. In doing this, great care should be exercised to make the holes sufficiently wide and deep, so that the roots are pointed downward and not doubled up in the hole; that the soil is well packed around them and that the plants are not set out deeper than when in the seedbed. More plants should never be removed at one time from the seedbed than what can be conveniently transplanted before they show signs of wilting, and the plants dug up should not be left exposed until the roots dry out. The plants should be thoroughly watered before and after transplanting, and the beds, kept from weeds and watered as often as necessary.

In the field.—Land overgrown with trees and shrubs should be cleared, the vegetation cut and burned during the driest period of the year, and the small stumps grubbed and burned together with the remaining logs. After this is done, the land is ready for staking and planting. Cogon land must be plowed and crossplowed and planted to legumes a year in advance of the planting of the coffee in order to destroy the cogon and im-

prove the soil. By this method, the plantation can be cultivated by animals and the cost of weeding is greatly lessened or reduced. The holes are dug from 80 to 100 cm deep and 40 to 60 cm in diameter, the size of the holes depending of course upon the character of the soil and the size of the plants to be transplanted. On light soil the holes can be dug smaller than on a heavy soil.

Where the land is slopping and the texture of the soil is of such a nature that it is easily washed away by rains, terracing should be done before planting the coffee. Trees in such areas will suffer from diseases and the yield fall off considerably. The terraces should follow the contour of the land, and should be so arranged as to hold the rain water and prevent soil wash. The lack of drains has been the cause of the rapid decline of many plantations in the Islands; therefore, the construction of ditches for draining off the extra water must also be undertaken wherever and whenever necessary.

Small seedlings having 5 to 6 pairs of leaves can be transplanted with or without a ball of earth with equally good results, but if larger seedlings are to be transplanted, it is advisable to provide each with a ball of earth in order to prevent a setback of the plants due to disturbance of the roots. About one-half of the foliage should be cut, and a trench dug at the end of the nursery bed to a depth of about 20 cm or more, depending upon the development of the roots. Then a thin, sharp bolo or spade should be passed through the soil underneath and around the plants, neatly severing all straggling roots and leaving the plant in the center of an oblong ball of earth. If the soil is so loose that it falls away from the roots when the plant is removed from the nursery, great care should be taken not to allow the roots to dry out and to set out the plant so that the roots will not be matted together in the center of the hole, but spread out in their natural position. The holes should be filled only with surface soil. In the course of planting, the soil should be worked in, and firmly packed about the roots, and the plant set out in the field at the same depth as in the nursery. Due care should be taken not to break the ball. Transplanting should be done preferably at the beginning of the rainy season to enable the seedlings to become rooted before the dry season. Young plants should on no account be transplanted during the dry weather unless irrigated, as a few days' hot sun will be fatal to them.

Spacing should be given careful consideration. If too close, the plants become crowded and the lower branches, deprived of sunlight, will shed their leaves and fall; if the distance is greater, the shade of the plants would not be sufficient to decrease soil erosion and evaporation of moisture. The distance and the number of plants to the hectare required for the different coffee varieties are as follows:

Variety	Distance in meter	Number of plants per hectare
Abeocuta	3.5–4.0	625– 816
Arabian	2.5–3.0	1,111–1,600
Canephora	2.5–3.0	1,111–1,600
Congo	2.5–3.0	1,111–1,600
Excelsa	4.0–4.5	493– 625
Dybowskii	4.0–4.5	493– 625
Liberian	3.5–4.0	625– 816
Mocha	2.5–2.5	1,600–1,600
Quillou	3.0–3.5	816–1,111
Robusta	3.0–3.5	816–1,111
Uganda	2.5–3.0	1,111–1,600

Shade.—The amount of shade to be provided in a coffee plantation depends upon the altitude. Less shade is needed where the sky is frequently overcast than where it is clear. As a rule coffee is shaded most heavily at the lowest elevation where it is grown, the need for shade decreasing with the rise in altitude. Opinions vary as to the best and most suitable tree for coffee shade. A particularly good shade in one locality may not prove so in another district. Trees that do not grow so large with a maximum spread of branches to shade a large area, fine leaves and not deciduous, are preferable for coffee shade wherever they grow. Besides, they should be subsoil feeders, capable of enriching the soil, not susceptible to diseases and pests attacking coffee, capable of standing against strong winds, quick growing, long-lived, with a big leaf fall, and suitable to the soil and climatic conditions of the place.

While it seems probable that ipil-ipil will be equally good for coffee shade in the Philippines as in Java, judging from the result obtained at Lamao, Bataan, still there may be exceptions to this rule. In Bukidnon and Basilan, Mindanao, for instance, the dapdap appears to be better than the ipil-ipil; in Lanao, Mindanao, the silk-oak and the dapdap appear to be desirable; while in Batangas, the madre-cacao is being commonly used.

Shade trees should be planted in advance so as to provide the proper shade at the proper time. If not, and the perma-

nent shade trees are not large enough to provide sufficient shade, a temporary shade should be planted at the same time the coffee seedlings are set out in the field. Cadios, castor bean and *Tephrosia* which are easily eradicated, are not likely to become weeds, and produce growths of leaves, for mulch makes excellent temporary shades for coffee.

It is always advisable to plant shade trees rather closely, and then gradually cut away the surplus branches, then the trees, leaving at the final thinning only one shade tree for every four coffee plants. If the permanent shade trees are allowed to develop too thickly and with too heavy branches, the coffee plants will grow tall with few and weak branches, longer internodes, and fewer berries, for too much or too little shade means reduced crop. Also dampness favors the development of fungi. After the elimination of all the unnecessary shade trees the branches of the permanent ones should be pruned off whenever necessary. Pruning should be done on every other row.

The easiest way of setting out ipil-ipil for shade tree is by cuttings obtained from the tops of old ipil-ipil trees, by inserting them in holes made with a crowbar during the rainy season, and by packing the soil well around them so that they remain firm in the ground. Dapdap or madre-cacao cuttings may be treated in the same way as the ipil-ipil.

If the shade trees are propagated from seeds, prepare a seedbed, sow and cover the seeds thinly with fine soil in rows from 20 to 25 cm apart. When the plants are needed for planting and cut them back to a height of about a meter and transplant them as in the case of the cuttings. Seeds can also be planted directly, if so desired.

CARE OF PLANTATION

Cultivation.—The land should be kept free from weeds with a cultivator, by hand-hoeing, or by cover-cropping. Cultivation should be done preferably a few days after the rains so as to conserve as much moisture as possible. Care should be taken so as not to injure the roots and branches while cultivating the open spaces between the coffee plants. When the coffee and shade plants are fully developed, only occasional hoeing is necessary.

Except where the land is exceptionally rich, it will be found advantageous to plant the vacant spaces between the coffee trees with some legumes for the first four years or until the

land is well shaded by the coffee and shade trees. This, if carried out properly, will minimize the cost of weeding, prevent soil erosion, and the rapid evaporation of soil moisture, and, if leguminous crops are planted, will enrich the soil.

In Java, ipil-ipil is planted on the edges and exposed places of the plantation, and in some cases, on steep land, ipil-ipil seeds are sown in a semicircular form in front of the coffee trees toward the bottom of the hill to prevent soil wash, and the ipil-ipil is continuously cut down to not more than two feet high. All the cut and dead branches are buried in the ground for green manuring.

Pruning.—If coffee trees are allowed to grow tall without topping, the harvesting and the treatment for diseases and pests will be very difficult, and they are also very liable to be blown down by strong winds. Furthermore, untopped trees have the peculiar habit of growing their branches near the ground and at the top, of leaving their middle bare or nearly so. This decreases the productivity of the plant. Top the plants when they are from 3 to 4 meters high and keep them at this height and allow no more than three stems to sprout from the ground by removing all superfluous shoots. This is to be done while the sprouts are still young, for at this stage they can be easily broken. All wild or water sprouts should be removed immediately so that long and spreading branches may be produced and the trees may be more fruitful. Unpruned trees cannot possibly yield a very profitable crop, and it is almost impossible to restore them at once. To induce the growth of more lateral branches, topping should be performed while the plant is still young or when it has made a growth of about a meter high.

Pruning, in order to be of benefit, should be done immediately after harvesting the crop, and should be finished before the flowering season. In pruning, clean cuts should always be made so that healing may take place at once, and all wounds should be painted with white lead or coal tar after the pruning has been performed to prevent the invasion of insects and fungi.

Conservation of soil fertility.—By proper crop rotation the fertility of the soil is more or less conserved. Coffee is a voracious nitrogen feeder, and therefore, this element should be given first consideration. The addition of nitrogen to the soil is done either by planting cover crops and plowing these under when fully matured or by adding artificial manures or fertilizers.

Various fertilizer mixtures have been reported to have given good results for coffee in other countries, but in the Philippines this result is problematical and should first be given a fair trial.

Control of pests and diseases.—There are several diseases and pests which attack the roots, stem, branches, leaves, flowers, and berries of coffee, but none of them has so far become serious in the Philippines except the blight and a root rot. The first one is so well known here that there is no need for its description. A remedial measure for blight has been worked out, but found very expensive in field practice. The root rot generally appears at the close of the rainy season in poorly drained land. During its early stage it can be controlled by disinfecting the injured portion with 4 per cent formalin solution. The first symptom of this disease is the yellowing of the leaves.

The mealy bug are sometimes very injurious to coffee flowers, but can easily be eradicated by spraying them with soap-sud solution.

Rejuvenation.—Considerable variations have been found in coffee, grown from seeds, and it is becoming generally recognized that budding and grafting from individual superior trees must be resorted to in order to obtain the best results. In the case of the hybrids, this operation is in fact absolutely necessary, since all the hybrids that have fruited so far in Java failed to come out true to type and produced exceedingly variable progeny, which in most cases was inferior to the hybrid parent.

In rejuvenating the old and unproductive coffee trees, manuring, cover-cropping, top-working, thinning, and planting of shade trees should be done, as the case may require. The old as well as the young unproductive trees may be made to bear fruits by top-working. This saves the expenses of planting news ones, and the trees so treated produce a crop within a shorter time. This method is as follows:

The trees should be lopped at a height of about 25 cm above the ground, as are the newly budded trees in the nursery. Numerous sprouts are soon produced from the stump. As soon as these sprouts are about 30 cm tall, the lopped part may be entirely severed from the stump and removed. Only two of the numerous suckers should be allowed to develop for grafting or budding with scions taken from a known productive tree. When the two newly grafted branches are well under way, cut off the poorest and leave only one to grow into a tree. Budding

or grafting the top-worked tree is performed in the same way as on young seedling stocks in the nursery except that the scions should be taken from the terminal branches only, for if budded or grafted with a horizontal scion, the resulting plant always develops into a low-spreading bush, and never produces vertical growth. Care should be taken to remove the wild or water sprouts as they appear.

HARVESTING AND PREPARATION

Picking the ripe berries from the nodes is done very roughly in the Philippines. No precaution is being taken not to injure the nodes, regardless of the fact that these parts are the permanent fruiting places of the coffee plants. Needless to say, this method of picking coffee berries should not be used. Avoid pulling the berries against their natural direction. They should always be pulled toward the outer end of the branches so as not to bruise any of the nodes. If this is not done, the productive capacity of the plant will be lessened as the plant gets old.

A clean and uniform product that will bring a good price is obtained by harvesting only the ripe berries.

In a crude way many planters still prepare coffee as follows:

1. The ripe berries with husks on are dried in the sun and husks, pulp, slime, hull, and part of the silverskin are removed by handmills or mortars and pestles or with the aid of a rice mill. This system of removing the silverskin can easily be done with Arabian coffee, but with the other kinds of coffee, like the Liberian and the Robusta types, the removal of the silverskin by this process is rather difficult. Pulping the fresh berries is now being facilitated by the use of a wooden roller devised at the Lamao Experiment Station.

2. The berries are first fermented for 24 hours, and after that, they are washed and dried in the sun until the inner skin separates readily when crushed or pounded in a wooden mortar. This method of drying requires much labor especially during the rainy season.

3. In preparing coffee on small scale, the red coating is peeled off, and then the berries are carefully washed. After this they are dried in the sun for 4 to 5 days or until they are ready to be crushed. When dried they are spread on flat boards, and a small wooden roller is rolled over them, thus breaking the second coating.

In Brazil, coffee is prepared in two ways; namely, by the dry and the wet systems. The dry method consists of spreading the

berries in the sun and protecting them from rains, and when they are dried, they are stored in dry places where the pulp is separated. By the wet method, the berries are submerged in a tank of water for several days; then the pulp is removed by trampling and dried afterwards.

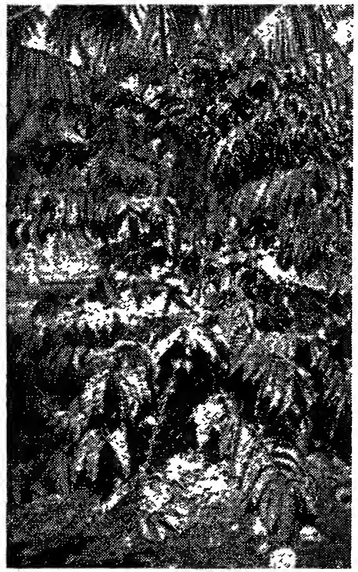
If the berries of the Liberian and the Robusta types are prepared by the aforementioned systems, after they are sun-dried the silverskin can be removed by moistening the beans and redrying them, then passing them through a hand rice mill or other suitable machine. If all the silverskin is not yet removed, the operation is to be repeated a second or third time. The silverskin of the sun-dried berries is very difficult to remove because, it is not loose unlike the hot air-dried berries where quick drying is done.

In factory practice, coffee is prepared as follows: After picking, the leaves, stones, dirt, and other impurities are removed. They are next washed in channels filled with water, and then brought to the pulping machine for pulp removal. The beans are then fermented in vats of water or in heaps for several days. The slimy substance is removed after fermenting the beans by washing. After washing, the berries are drained on galvanized iron plate, perforated with circular holes, and then dried as quickly as possible. But in order to command a good price in the world market, the Robusta and the Liberian types require artificial drying in especially constructed dryers. To remove the silverskin the dried beans are passed to a huller as many as two or three times.

LIST OF ILLUSTRATIONS

PLATE 1

1



2

3

PLATE 2

BUREAU OF PLANT INDUSTRY

AGRICULTURAL STATIONS

1. Central Experiment Station, Manila
2. Lamao Horticultural Station, Limay, Bataan
3. Lipa Coffee-Citrus Station, Lipa, Batangas
4. Tanauan Citrus Station, Tanauan, Batangas
5. Granja Sugar-Cane Station, La Granja, Occidental Negros
6. Gandara Seed Farm, Gandara, Samar
7. Baguio Plant Industry Experiment Station, Baguio
8. Maligaya Rice Station, Muñoz, Nueva Ecija
9. Ilagan Tobacco Station, Ilagan, Isabela
10. Maridagao Rubber Station, Pikit, Cotabato
11. La Paz Propagation Station, La Paz, Iloilo
12. Los Baños Economic Garden, Los Baños, Laguna
13. Sta. Maria Propagation Station, Sta. Maria, Ilocos Sur

SUBSTATIONS

1. Davao Seed Farm, Davao Penal Colony, Davao
2. Halcon Rubber Substation, Baco, Mindoro
3. Gingoog Lanzon Reservation, Gingoog, Oriental Misamis
4. Mandaue Seed Farm, Mandaue, Cebu

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Manuscripts intended for publication in the Philippine Journal of Agriculture should be sent to the Chief, Publications Division, post-office box 613, Manila, Philippine Islands.

One hundred separates of each paper published in the Journal are furnished to the author without charge. Additional copies may be had at the author's expense if ordered when the manuscript is submitted for publication.

The journal is issued quarterly. The subscription price is 2 pesos (Philippine currency) or 1 dollar (United States currency) per year in the Philippine Islands and the United States and territories; 2 dollars (United States currency) in foreign countries. Single copies are sold at the same rates.

Subscriptions should be sent to the Chief, Publications Division, Department of Agriculture and Commerce, post-office box 613, Manila, P. I.

Publications sent in exchange for the Philippine Journal of Agriculture should be addressed: Scientific Library Division, Bureau of Science, Department of Agriculture and Commerce, post-office box 774, Manila, P. I.

VOL. 9 THIRD QUARTER, 1938 NO. 3

The Philippine Journal of Agriculture

PUBLISHED QUARTERLY BY

THE DEPARTMENT OF AGRICULTURE AND COMMERCE

MANILA
BUREAU OF PRINTING
1938

22680

DEPARTMENT OF AGRICULTURE AND COMMERCE

Hon. EULOGIO RODRIGUEZ, A.B., *Secretary*
Hon. JOSE S. CAMUS, B Agr., *Under-Secretary*

THE PHILIPPINE JOURNAL OF AGRICULTURE

Published quarterly by the DEPARTMENT OF AGRICULTURE AND COMMERCE
Editorial Offices: DIVISION OF PUBLICATIONS, Oriente Building, Plaza Binondo, Manila

[Entered at the Post Office at Manila, Philippines, as second-class matter]

The Philippine Journal of Agriculture

VOL. 9 THIRD QUARTER, 1938 No. 3

ACCLIMATIZATION OF SOYBEAN IN THE PHILIPPINES: I

By P. A. RODRIGO

Of the Horticulture Section
Bureau of Plant Industry, Manila

SIX PLATES

Work on the acclimatization of the soybean, *Glycine max* M., was started by the then Bureau of Agriculture (now Bureau of Plant Industry) in 1911, and as early as 1915 by the College of Agriculture in Los Baños. From 1911 to 1932, about 100 varieties from various countries have been introduced and tested by the former institution. The present work, however, the results of which are being presented in this paper, was begun in May, 1935, and is still in progress.

When the Bureau of Plant Industry first launched its drive on crop diversification in 1931 or thereabout, there was an apparent need for some crops that could be used in our scheme of crop diversification. Because of the great value of soybean in China and Japan as a staple food crop, and its rapidly increasing importance and popularity in the United States and in Europe, together with the fact that the Philippines imports annually over half million-peso worth of this commodity and its products, the soybean was then considered as a potential crop for diversification. The successful production of soybean in the Philippines would not only prove agriculturally beneficial, but it would also bring a decided improvement in the diet of our people, the soybean being considered to be the "most complete and natural food known to the human race" (3).

The soybean is not really a new crop in the Philippines, although it is practically unknown to the farming public. Some even advance the theory that it is indigenous to the Philippines

(3); but the more common belief is that it must have been introduced here during the early Spanish times, perhaps, by Chinese immigrants. This belief is strengthened by the lack of any wild species or form of soybean in the Islands and by the existence of only a single naturalized variety, the Ami, which is claimed to have been grown in the province of Batangas from time immemorial. Although it grows well under local conditions, this variety is small-seeded, late, and irregular in maturity, and not very productive in grains. It is more useful as a forage rather than as a food crop.

The desire to find new varieties adapted to Philippine conditions which would give greater production, mature earlier, and if possible have bigger grains than the Ami was the main objective of this study.

The data presented in this article include results obtained from cultures started in May, 1933 to June, 1937. All the tests were conducted in plot cultures at the Central Experiment Station, Malate, Manila. The field trial tests of the promising varieties in different stations of the Bureau will be reported later in a separate paper.

REVIEW OF PREVIOUS WORK

A number of sporadic attempts to grow soybean in the Philippines was made. In general, these early introductions did not give encouraging results, perhaps, because of the lack of knowledge of the cultural requirements of the plant, or the varieties introduced were not adapted to Philippine conditions. "Variety trials at Singalong and Batangas gave returns of forage and seed that were unsatisfactory. At Alabang and Lamao, the plants grew normally in every way, but were one-third smaller than plants of the same variety in Virginia" (9). Foreign varieties tested by Layosa (7) in the Philippine College of Agriculture did not show promising results.

A rainy and a dry season tests made by the writer in the College of Agriculture, Los Baños in 1924–1925, of several varieties from the Illinois Agricultural Experiment Station, U. S. A., did not also give much promise. Platon,(10) on the other hand, reports that in a year's test of nine newly introduced soybean varieties in the Los Baños College of Agriculture, he found Head Green and American Black promising but not as productive as the Ami.

The progress of the soybean work in the United States was also very slow. Mease (9) wrote as early as 1904 that "the

soybean bears the climate of Pennsylvania very well" and that he recommended its cultivation. Subsequently, although at a much later date, the different state experiment stations of the United States including the United States Department of Agriculture undertook extensive studies of the soybean. Hackleman et al. (4) reported that more than 2,000 varieties and strains were studied and described in the United States, out of which only about 40 were recommended for commercial planting(3). in 1928, it was reported that 45 varieties and over 100 new strains have been tested in the Illinois Agricultural Experiment Station(4). Gray(3) also states that in England over 200 varieties have been tested, out of which only four have been considered to be good for commercial planting there.

While some recommendations were made as early as 1804(9) for the cultivation of soybean in the United States, it was only in 1890 when some farmers undertook its cultivation on a commercial scale(3). The history of the development of the soybean industry in the United States simply emphasizes the difficulties with which a new crop wins its way to recognition. But the soybean success was decisive, as according to Gray(3) "there is no agricultural product that has increased so rapidly in the past decade as the soya plant which has a larger yield of beans than any known legume."

MATERIALS AND METHODS

In this work, advantage was taken of the results of similar work in the United States, Japan, China, Hawaii(1), and India in that only varieties known to be productive have been introduced. Fifty-six varieties have been tested in connection with this study. Table 2 presents the varieties tested, the date of introduction, and the country of origin.

The varieties used in this study were not all tested at the same time because of limited labor, neither were they all tested throughout the duration of the experiment. Five to fifteen varieties were tested in one season. The scheme of the study was by trial and elimination, but a variety was tested at least for two or more seasons before it was eliminated. Out of a number of varieties tested in two seasons, only those found promising by actual performance were planted in the following season together with a batch of newly introduced seeds to replace those that have been discarded. Thus, it will be seen that some varieties were included in practically all the tests while others were tested only in two or more seasons.

TABLE 1.—*Varieties tested and the country of origin.*

Variety name	P. I. number	Date when received	Source
Virginia Early Brown	11439	Mar. 9, 1933	Ohio Experimental Station, U. S. A. [1]
Wilson Early Black	11440	Mar. 9, 1933	Do.
Midwest	11442	Mar. 9, 1933	Do.
Akita	11616	May 16, 1933	Yokohama Nursery, Japan.
Hakubi	11617	May 16, 1933	Do.
Furisode	11618	May 16, 1933	Do.
Otama-ao	11619	May 16, 1933	Do.
Otama-ao Str. 2 [2]	-------	---------------	
Otama-ao Str. 3 [2]	13870		
Chinese [3]	-------		Shanghai, China.
Dunfield	12552	May 16, 1934	Illinois Experimental Station, U. S. A.
Illini	12553	May 16, 1934	Do.
Manchu	12554	May 16, 1934	Do.
Mandarin	12555	May 16, 1934	Do.
Macoupin	12556	May 16, 1934	Do.
Cayuga	12798	Feb. 22, 1935	New York Agricultural Experimenta Station, U. S. A.
American Sweet Black	12975	Sept. 25, 1935	College of Agriculture, Los Baños.
Yue Yin Sept. Yellow	12976	Sept. 25, 1935	Do.
Shangtung No. 1	13121	Feb. 26, 1936	Lingnan University, China.
Shangtung No. 2	13122	Feb. 26, 1936	Do.
Lingnan No. 1	13123	Feb. 26, 1936	Do.
Lingnan No. 2	13124	Feb. 26, 1936	Do.
Kuala Lampur No. 1	5309	Oct. 2, 1936	Federated Malay States.
Kuala Lampur No. 2	5310	Oct. 2, 1936	Do.
E. B. 3656	5311	Oct. 2, 1936	Do.
Laredo	5315	Oct. 8, 1936	Hawaii Agricultural Experiment Station.
Nanking	5316	Oct. 8, 1936	Do.
Seaweed	5317	Oct. 8, 1936	Do.
Yellow Biloxi Hybrid	5318	Oct. 8, 1936	Do.
Manchuria [4]	13252	Nov. 6, 1936	Manchuria, China.
Kingwa	13266	Oct. 21, 1936	Virginia Experimental Station, Virginia.
Punjab Chocolate No. 1	13292	Feb. 1, 1937	India.
Punjab Chocolate No. 2	13293	Feb. 1, 1937	Do.
Punjab Yellow Late Italian	13294	Feb. 1, 1937	Do.
Kachin	13716	Mar. 16, 1937	Do.
Penagype	13717	Mar. 16, 1937	Do.
	13770	Apr. 19, 1937	Ceylon.
Mis 1 Pe-Ungype	13782	May 6, 1937	India.
Mis 2 Behrum	13783	May 6, 1937	Do.
Mis 28 E. B. Str. 3910	13784	May 6, 1937	Do.
Mis 33 Dixi	13785	May 6, 1937	Do.
Nanksoy	13786	May 13, 1937	China.
Head Green	14229	May 25, 1937	College of Agriculture, U. P.
American Black	14230	May 25, 1937	Do.
Mamloxi	13850	June 5, 1937	Mississippi, U. S. A.
Mamredo	13851	June 5, 1937	Do.
Manchuria 13–177	13852	June 5, 1937	Illinois Agricultural Experiment Station, U. S. A.
Type 117	13853	June 5, 1937	Do.
Type 65379	13854	June 5, 1937	Do.
Mandell	13855	June 5, 1937	Do.
Scioto	13856	June 5, 1937	Do.
Yellow Big	13863	June 18, 1937	India.
Brown	13864	June 18, 1937	Do.
Black	13865	June 18, 1937	Do.
Yellow small	13867	June 18, 1937	India.
Green	13866	June 18, 1937	Do.

[1] Obtained from the cultures of Mr. Manas who was then in charge of soybean and other legume projects.

[2] Selection from Otama-ao.

[3] The seed was confiscated at the Customhouse; shipment came from China, hence the variety name "Chinese."

[4] The seed was imported from Manchuria without name, hence the name "Manchuria."

Tests were made both during the rainy season and the dry season. The idea was primarily to determine the behaviour of the newly introduced varieties when planted at different times of the year and secondarily to enable the multiplication of the promising varieties more rapidly and to insure the supply of viable seeds since soybean is known to lose its vitality in the tropics when kept long in storage(12).

DESCRIPTION OF VARIETIES

No attempt was made to describe the different varieties in detail as was done by Etheridge et al.(2), Morse(8), and Kinney(6). Rather, only the important characters that would easily distinguish a variety from another were taken into consideration. It may be stated here, however, that varietal characters are always more or less variable, being affected by time of planting, seasonal conditions, soil, and other environmental factors. The descriptions here presented were based on characters as they were observed at the Central Experiment Station, Manila.

Wilson Early Black.—Introduced from the Ohio Experiment Station. The plant is slender, medium erect, and has the tendency to twine at the tip; internodes quite long. It grows from about 30 to 70 centimeters. Flower purple; pod gray when matured and fairly well distributed along the vine. The seed is small, oblong, and flattened; seed coat black; hilum black; but cotyledon yellow.

Virginia Early Brown.—Introduced from the Ohio Experiment Station. The plant is slender, and has the tendency to be viny; internodes quite long. Height of plants from about 30 to 50 centimeters. Flower purple; pod tawny when dry, and it is thinly scattered along the stem; seed small, oblong, and flattened; seed coat greenish brown; hilum olive brown; and cotyledon yellow.

Midwest.—Introduced from the Ohio Agricultural Experiment Station. The plant is bushy and erect with medium stem growing to a height of from about 20 to 45 centimeters. (Plate 2, fig. 9). Flower purple; pod tawny when dry; pod formation on central stem terminates abruptly at the tip. Seed medium in size, globose in lateral outline; testa not glossy and buff in color; hilum light to dark brown in color; cotyledon yellow (Plate 6, fig. 20).

Akita.—Of Japanese origin. Plant is bushy and dwarf, growing to a height of from 15 to 25 centimeters. Pod forma-

tion, compact on central stem and ending abruptly at the tip. Pod straw-colored when dry; seed medium small in size; testa glossy and light yellow in color; cotyledon yellow.

Hakubi.—Introduced from Japan. The plant is bushy and erect with practically no branch (Plate 2, fig. 10). Stem coarse and may attain a height of from 20 to 40 centimeters. Internodes are short, and pod formation on central stem, and denser towards the base. Flower purple; pod light brown; seed, medium large, ovoid in shape; testa white; cotyledon yellow (Plate 6, fig. 7).

Furisode—From Japan. The plant is dwarf with few or no branches (Plate 2, fig. 8). The stem is very coarse and attains a height of from 20 to 40 centimeters. Pod formation is bunchy, thicker towards the base, and has a tawny color. Seed large, mostly ovoidal in outline; seed coat greenish brown and not glossy; hilum dark brown; cotyledon greenish yellow (Plate 6. fig. 6).

Otama-ao.—Of Japanese origin. The plant is dwarf and erect, attaining a height of from 15 to 30 centimeters. Hilum coarse; pod formation bunchy (Plate 2, fig. 7). Flower purple; pod brown; seed mostly globose in shape; seed coat dull buff; hilum slate; cotelydon yellow (Plate 6, fig. 26).

Otama-ao Str. 2.—A strain isolated from Otama-ao. The plant is erect, medium-sized, and with coarse stem that has the tendency to branch (Plate 2, fig. 11); pubescence tawny; flowers purple; pods dark brown and are more or less clustered along the stem but mostly towards the lower zone of the stem. Seed, of medium size, ovoidal in lateral outline; testa creamy buff in color and glossy; hilum black with yellow median line; cotyledon yellow (Plate 6, fig. 27).

Otama-ao Str. 3.—Also a strain isolated from Otama-ao (see Plate 2, fig. 1). It attains a height of from 30 to 60 centimeters. Flower purple; pubescence tawny; seed, of medium size, ovoidal in lateral outline; testa yellowish green; hilum royal brown; cotyledon light green (Plate 6, fig. 28).

Chinese.—Of Chinese origin. The plant is bushy and erect; stem, of medium size; pubescence tawny; pods light brown when matured and fairly well scattered along the stem (Plate 3, fig. 5). Plant attains a height of from 20 to 50 centimeters. Seed globose in lateral outline, of medium size; testa not glossy and creamy buff; hilum rather small and chamois in color; cotyledon yellow (Plate 6, fig. 4).

Dunfield.—Of Manchurian origin (4) but directly introduced from Illinois Experiment Station. Plant erect; stem medium coarse; pubescence gray; flowers mostly purple; and pods brown. Pod formation is along central stem and prolific (Plate 3, fig. 8). Seed ovoidal to globose in lateral outline; seed coat creamy buff; hilum dark brown; cotyledon yellow (Plate 6, fig. 5).

Illini.—Introduced from Illinois Experiment Station. The plant is erect with few or no branches. Stem rather small; pubescence gray; flower white; pod brown. Its pod formation is on the central stem (Plate 3, fig. 6). Seed medium-sized, globose to ovoidal in lateral view; testa ivory yellow; hilum light brown; cotyledon yellow (Plate 6, fig. 9).

Manchu.—Of Manchurian origin (4) but directly introduced from Illinois Experiment Station. Plant erect and bushy; stem medium-sized but coarse; pubescence tawny; flowers both purple and white; pod dark brown. Pod formation on central stem, prolific (Plate 3, fig. 7). Seed medium large, glossy, mostly ovoidal in shape; testa ivory yellow; hilum dark brown; cotyledon yellow (Plate 6, fig. 13).

Mandarin.—Originally from Manchuria (4) but directly obtained from Illinois Experiment Station. Plant erect and of medium size; stem and leaves, medium-sized; pubescence gray; flower purple; pod forming along central stem and terminating abruptly (Plate 3, fig. 4), gray in color; seed medium large, ovoidal to globes in shape; testa dull buff; hilum dull brown; cotyledon yellow (Plate 6, fig. 16).

Macoupin.—Introduced from the Illinois Experiment Station. Plant erect and bushy, attaining a height of from 30 to 90 centimeters. Stem and leaves medium-sized; pubescence gray; pod formation on central stem, prolific (Plate 3, fig. 9); pod dark gray; seed medium large, oblong to almost spherical, glossy; testa orange yellow; hilum pinkish cinnamon; cotyledon yellow (Plate 6, fig. 12).

Yellow Biloxi Hybrid.—Introduced from the Hawaii Experiment Station. Plant medium large, erect and bushy (30 to 95 centimeters high). Stem big and coarse; flower purple; pubescence tawny; pod formation on central stem, terminating abruptly at tip, and prolific (Plate 2, fig. 2). Pod dark buff, big; seed large, slightly flattened, ellipsoidal to ovoidal in lateral outline; testa cream buff, glossy; hilum dark brown; cotyledon yellow (Plate 6, fig. 34).

Nanking.—Introduced from the Hawaii Experiment Station. Plant erect, dwarfed, bunchy, and compact (Plate 2, fig. 5).

Stem medium coarse; pubescence tawny; flowers purple; pod formation on central stem, dense and compact; pod brown; seed, of medium size, ovoidal to globose in lateral outline; testa light buff and glossy; hilum dark brown; cotyledon yellow (Plate 6, fig. 24).

Nanksoy.—Introduced from Lingnan University, Canton, China. Plant erect, dwarfed. Stem medium coarse; leaves dark green; pubescence tawny; flower purple; pods tawny bunchy and compact (Plate 2, fig. 6). Seed medium, ovoidal to globose in lateral outline; testa creamy buff; hilum light brown; cotyledon yellow (Plate 6, fig. 25).

Seaweed.—Introduced from Hawaii Agricultural Experiment Station. Plant erect, dwarfed, stem medium coarse; pubescence tawny; flowers purple; pods large formed on central stem in a bunchy and compact manner (Plate 2, fig. 4). Seed large, slightly flattened, ellipsoidal in lateral outline; testa greenish buff with black saddle around hilum; hilum light ash; cotyledon yellow (Plate 6, fig. 31).

Kingwa.—Introduced from the Virginia Experiment Station. Plant erect, stem medium in size but stiff; pubescence gray; flower purple; pod light brown and formed rather sparsely along the central stem, terminating abruptly at tip (Plate 2, fig. 3). Seed, of medium size, slightly flattened, ovoidal in lateral outline; testa black; cotyledon black (Plate 6, fig. 11).

Head Green.—An American soybean but directly introduced by the Philippine College of Agriculture. Plant slender, tall, semi-erect tending to twine slightly at tip (Plate 3, fig. 2); pubescence gray; flower purple; pod dark brown and well distributed throughout the stem and branches; seed small, oblong, and slightly flattened; seed coat yellowish green; hilum light brown; cotyledon yellow (Plate 6, fig. 8).

American Black.—Of the United States origin but directly introduced by the Philippine College of Agriculture. Plant tall and rather slender; pubescence tawny; pod dark brown; seed small ovoidal to ellipsoidal in lateral outline; testa black; hilum black with light marking; cotyledon light green (Plate 6, fig. 1).

Kachin.—Introduced from India. The plant is bushy and erect and of the branching type; pod formation bunchy (Plate 4, fig. 3). Stem distinctly coarse; flower purple; pubescence white; pod brown; seed medium small, truncate in lateral outline; testa light yellow; hilum brown; cotyledon yellow (Plate 6, fig. 10).

Penagype.—Introduced from India. The plant is viny and produces many fine branches. Stem fine; flower purple; pubescence gray; pod brown, formed sparsely, and is borne towards the upper half of the vine. Seed very small, subuniform, rather flattened; testa greenish yellow; hilum light brown; cotyledon yellow (Plate 6, fig. 29).

Mis 2 Behrum.—Of Indian origin. Very similar to Kachin in practically all respects (Plate 4, fig. 4) except that the grains are slightly smaller and the pubescence is gray (Plate 6, fig. 21).

Mis. 28 F. B. Str. 3910.—Introduced from India. Plant tall; stem and leaves large and rather coarse; flower white; pubescence gray; pod light brown and clustered along main stem; and branches terminating abruptly at tip (Plate 3, fig. 1). Seed medium small, globular to ovoidal in shape; testa creamy buff, glossy; hilum light brown; cotyledon yellow (Plate 6, fig. 22).

Mis 33 Dixi.—Of Indian origin. Plant tall and is very similar to Mis 28 E. B. Str. 3910 in practically all respects (Plate 3, fig. 3 and Plate 6, fig. 23).

Mamloxi.—Introduced from Mississippi, U. S. A. Plant erect; stem, of medium size but stiff; pubescence gray; flower purple; pod light buff, formed rather compactly along central stem, terminating abruptly at tip. Seed medium large, globose to ovoidal in lateral outline; testa glossy and creamy buff; hilum faint light brown; cotyledon yellow (Plate 6, fig. 18).

Mamredo.—Introduced from Mississippi. Plant erect; stem, of medium size and rather coarse; pubescence tawny; flower white; pod deep buff, formed along central stem, terminating abruptly at tip. Seed, of medium size, globose; testa light buff; hilum prominent and brown; cotyledon yellow (Plate 6, fig. 19).

Scioto.—Introduced from the Illinois Experiment Station. Plant erect; stem, of medium size but rather coarse; pubescence white; flower white; pod dark brown, formed rather compactly along central stem, terminating abruptly at tip. Seed, of medium size, ovoidal to ellipsoidal in shape; testa greenish buff, glossy; hilum prominent and dark brown; cotyledon yellow (Plate 6, fig. 30).

Mandell.—From the Illinois Experiment Station. Plant erect; stem, of medium size; pubescene gray; flower purple; pod straw-colored and borne on central stem, terminating abruptly at tip. Seed large, ovoidal in shape; testa greenish buff; hilum rather prominent and dark brown; cotyledon yellow (Plate 6, fig. 17).

Type 65379.—From the Illinois Experiment Station. Plant erect, stem, of medium size; pubescence gray; flower purple; pod dark brown, borne on central stem, terminating abruptly at tip. Seed, of medium size, globose to ovoidal in lateral outline; testa creamy buff; hilum light brown; cotyledon yellow (Plate 6, fig. 33).

Yellow Big.—Introduced from India. Plant erect; stem coarse; pubescence white; flower purple. Pod brown, rather compact on central stem. Seed medium small; ellipsoidal to truncate in form; hilum prominent, brown; cotyledon yellow.

CULTURES

A total of 14 sets of planting was made in connection with this study, extending for a period of four years, from June, 1933 to the early part of 1937. Seven rainy season cultures were made against seven during the dry season. Two of the dry-season cultures were considered a failure because of the low percentage stand of the crop caused by excessive rain just after planting. Data here presented, therefore, were obtained from only 10 of the cultures, five representing rainy-season cultures, and another five dry-season cultures.

All the cultures were made at the Central Experiment Station, Manila, in garden plots. This fact should be borne in mind in connection with the computed yields per hectare as will be presented later in this paper. Table 2 presents the different sets of cultures, giving the date of planting and of harvesting or maturity.

TABLE 2.—*Dates of planting and harvesting of the different cultures.*

Culture number	Date planted	Date harvested	Remarks
A	June 21, 1933	August 25–September 24, 1933	Rainy-season culture.
B	Oct. 16, 1933	December 22–January 8, 1934	Dry-season culture.
C	Feb. 18, 1934	April 26–May 6, 1934	Do.
D	July 8, 1934	September 24–October 10, 1934	Rainy-season culture.
E	Oct. 13, 1934	January 2–14, 1935	Dry-season culture.
F	Feb. 21, 1935	May 23, 1935	Do.
G	Apr. 3, 1935	July 2, 1935	Rainy-season culture.
H	June 2, 1935	August 22, 1935	Do.
I	Oct., 1935		Dry-season culture.
J	Mar. 18, 1936	June 25, 1936	Do.
K	June 5, 1936	September, 1936	Rainy-season culture.
L	Oct. 10, 1936		Dry-season culture.
M	June 2–6, 1937	August 19–October 23, 1937	Rainy-season culture.
N	July 6, 1937	September 19–November 29, 1937	Do.

Culture A was started with seven varieties; namely, Akita, Furisode, Habuki, Midwest, Otama-ao, Wilson Early Black, and Virginia. At harvest time, two distinct types—dwarf and tall plants—were found in the plots planted to Otama-ao. Because the dwarf plants were predominant they were considered as representing the genuine Otama-ao. The tall plants were called Otama-ao Str. 2. In Str. 2, a few plants with yellow seeds were found; these were again isolated and were labelled in the following culture as Otama-ao Str. 3.

The same varieties in Culture A were the subject of study in Culture B, but instead of having only seven varieties, nine were tested because of the two strains isolated from Otama-ao. In Culture C, again the same varieties in the previous cultures were used with one new addition—Chinese. In Culture D, 11 varieties were tested, namely, Chinese, Dunfield, Furisode, Hakubi, Illini, Macoupin, Manchu, Mandarin, Midwest, Otama-ao Str. 2) and Otama-ao Str. 3. The same varieties were tested in Culture E; Otamao-ao, however, was also included. In Culture F, two new varieties—Cayuga and Manchuria—were added, bringing the total number of varieties tested in this culture to 14.

In Cultures G and H only the three most promising varieties—Dunfield, Macoupin, and Manchu—were tested. The main idea was to test these varieties on a bigger scale and at the same time to produce more seeds for trial planting in some of the experiment stations in the provinces. Culture I was represented by 17 varieties, but the percentage of germination was very low because of excessive rain which followed the planting. In Culture J, seven varieties were tested while in Culture K, only six were included. In Culture L, a number of new varieties including Nanking, Seaweed, Yellow Biloxi Hybrid, and others were tested with the old promising varieties. Culture M was represented by 21 varieties with 12 newly introduced varieties mostly from India, while in Culture N, 12 newly introduced varieties were tested using Macoupin as the basis for comparison.

In Cultures A, B, C, D, E, and F, the planting was done by means of bed system, that is, plots one meter wide and 10 to 20 meters long were prepared for planting, putting two rows in each plot spaced at 50 centimeters far apart. In the rest of the cultures, the seeds were planted in rows set at 80 centimeters far

apart, each variety occupying a row and replicated four or more times. The hills in all cases were planted at 25 centimeters in the rows, allowing two plants to grow in a hill.

In this study, the results may be grouped into two—field observations and experimental data. The field observations were made from planting to maturity, noting down the general behaviour of the different varieties thus enabling the writer to make the general descriptions of said varieties. The experimental data which constitute the main bulk of the results were gathered after the plants were harvested. In the gathering of experimental data the weight of the grains per plant or row was considered as the main criterion for comparison. In some cases the air-dry-weight of the vines and also their heights at maturity were taken.

In the whole acclimatization test, no inoculation was made. However, the different soybean varieties were examined from time to time for their nodule formation, although no critical study on this subject was ever attempted in the present paper. As much as possible, the different cultures, especially the varieties in the same culture, were given practically the same cultural treatments particularly with respect to preparation of the land, cultivation, and weeding.

Owing to the great bulk of the data gathered in this study, it was deemed necessary to present only the summary result of each culture.

EXPERIMENTS AND RESULTS

Culture A.—This was a rainy-season culture; it was conducted from June to September of the year 1933. In spite of the fact that the plots were partially under water during the development of the plants the stand of the crop in general was good. The average height of the different varieties varied from 21.13 ± 0.17 to 61.96 ± 0.91 centimeters. The plants showed rather high resistance to standing water—much more than other field legumes like cowpea and mongo. The maturity of the latest maturing variety was overtaken by a 48-hour of more or less continuous rain spell. This caused the decay of the maturing grains. Table 3 gives a summary of the results of this culture.

TABLE 3.—*Average height, weight of straw, and yield of grains of different varieties of soybean, June to September, 1933 planting.*

Variety name	Average height of plant	Average weight of straw per plant	Average weight of beans per plant
	cm.	*gm.*	*gm.*
Akita	21.13±0.17	4.36±0.15	1.14±0.09
Furisode	36.32±0.26	9.22±0.23	8.31±0.13
Hakubi	38.29±0.47	10.87±0.32	9.77±0.24
Midwest	43.06±0.53	13.03±0.37	10.43±0.23
Otama-ao	27.49±0.17	6.91±0.19	7.32±0.17
Otama-ao Str. 2	50.35±0.69	11.50±0.05	7.32±0.14
Wilson Early Black	61.96±0.91	13.36±0.48	8.32±0.19
Virginia [1]	----------	----------	----------

[1] The maturity of this variety coincided with continuous rain, thus causing the crop to rot.

Culture B.—This culture was undertaken during the early dry season of 1933, from October to December. Nine varieties were tested. While the plants were smaller in size than those in Culture A, the quality of the grains produced was far superior. The average height of the plants varied from 23.02 ± 0.27 to 44.50 ± 0.32 centimeters. Table 4 presents the summary results of this study.

TABLE 4.—*Mean height, weight of straw, and yield of grains of different varieties of soybean, October to December, 1933 planting.*

Variety name	Average weight of plant	Average weight of straw per plant	Average weight of beans per plant
	cm.	*gm.*	*gm.*
Akita	23.02±0.27	5.41±0.19	5.01±0.11
Furisode	26.56±0.32	5.53±0.25	3.93±0.19
Hakubi	32.80±0.41	9.25±0.27	9.04±0.28
Midwest	30.70±0.49	7.75±0.35	6.66±0.28
Otama-ao	25.30±0.04	5.80±0.14	6.34±0.15
Otama-ao Str. 2	36.52±0.46	8.50±0.26	7.75±0.20
Otama-ao Str. 3	39.99±0.51	8.80±0.32	8.29±0.25
Virginia	44.50±0.32	8.98±0.25	6.50±0.15
Wilson Early Black	39.31±0.64	7.06±0.28	6.35±0.21

Culture C.—This culture was a late dry-season crop. It was planted in February and harvested in April to the early part of May, 1934. The plants looked more dwarfish than the previous two cultures of the same variety; the average height of plants here ranged from 18.16 ± 0.27 to 32.32 ± 0.55 centimeters. Being a dry-season crop, however, the quality of the grains was very good. Table 5 gives a summary of the results of this study.

TABLE 5.—*Mean height, weight of straw, and yield of grains per plant of different varieties of soybean, February, April, and May, 1934 crop.*

Variety name	Average height of plant	Average weight of straw per plant	Average weight of beans per plant
	cm.	*gm.*	*gm.*
Akita	18.16 ±0.27	4.90 ±0.14	4.88 ±0.13
Chinese	23.71 ±0.45	4.33 ±0.20	4.60 ±0.19
Furisode	20.23 ±0.39	5.23 ±0.20	6.21 ±0.21
Hakubi	22.78 ±0.28	6.16 ±0.20	7.67 ±0.19
Midwest	22.21 ±0.32	6.46 ±0.18	7.22 ±0.17
Otama-ao	16.72 ±0.16	4.06 ±0.11	4.36 ±0.10
Otama-ao Str. 2	29.17 ±0.45	8.23 ±0.27	8.43 ±0.25
Virginia	32.32 ±0.55	7.42 ±0.25	5.16 ±0.11
Wilson Early Black	29.71 ±0.60	6.64 ±0.26	5.73 ±0.16

Culture D.—Another rainy-season culture. It was planted in July, 1934 and harvested in the latter part of September to the early part of October of the same year. Again, the different varieties showed that they grew taller than those planted from October to January, the average height varying from 28.60 ± 0.51 to 72.73 ± 0.51 centimeters. In this culture the varieties with poor performance in the previous tests were eliminated, and new ones were included. The summary of the results of this test is presented in Table 6.

TABLE 6.—*Mean height, weight of straw, and grain yield per plant of different varieties, July to September and October, 1934 planting.*

Variety name	Average height of plant	Average weight of straw per plant	Average weight of beans per plant
	cm.	*gm.*	*gm.*
Chinese	44.10 ±0.43	8.26 ±0.19	4.94 ±0.12
Dunfield	48.43 +0.46	8.56 ±0.22	7.97 ±0.22
Furisode	28.60 ±0.51	9.73 ±0.58	3.92 ±0.35
Hakubi	38.20 ±0.59	10.15 ±0.48	7.02 ±0.37
Illini	56.01 ±0.29	6.49 ±0.12	7.17 ±1.10
Macoupin	72.73 ±0.51	13.09 ±0.20	12.25 ±0.23
Manchu	49.30 ±0.52	6.07 ±0.14	6.05 ±0.14
Mandarin	51.94 ±0.49	7.54 ±0.18	6.01 ±0.17
Midwest	40.36 ±0.63	12.16 ±0.40	7.30 ±0.39
Otama-ao Str. 2	42.10 ±0.59	7.87 ±0.30	4.35 ±0.16
Otama-ao Str. 3	46.09 ±0.61	9.79 ±0.32	6.63 ±0.22

Culture E.—A dry-season planting. The first one was planted under a semi-field condition in October, 1934 and harvested in early January, 1935. Being a dry-season crop, the grains were very good and attractive. Four varieties in this test showed great promise as seen in Table 7 wherein the summary of the results of this culture are presented. These varieties were

Manchu, Macoupin, Dunfield, and Illini—all from the Illinois Experiment Station, U. S. A. The plants were also rather dwarf.

TABLE 7.—*Mean yield of straw and grains of 15-meter row spaced at 50 cm. far apart, October, 1934 to January, 1935 crop.*

Variety name	Average yield of straw of 15-meter row	Average yield of grains of 15-meter row	Computed yield per hectare
	gm.	*gm.*	*kg.*
Chinese	385.5±30.93	307.2±27.72	410
Dunfield	460.7±19.46	552.3±16.22	736
Furisode	52.1± 5.77	65.7± 9.81	88
Hakubi	323.5± 6.54	265.1±14.64	353
Illini	416.1±10.37	542.9± 9.99	724
Macoupin	648.8± 6.38	557.4± 9.45	743
Manchu	624.7± 2.32	595.0± 1.99	793
Mandarin	295.2±15.48	347.7± 9.63	483
Midwest	298.1± 9.68	325.8± 9.12	434
Otama-ao	179.6±14.06	185.9±18.95	247
Otama-ao Str. 2	347.3±26.74	320.4±28.33	427
Otama-ao Str. 3	452.1± 8.33	413.5± 8.84	559

Culture F.—This was a late dry-season crop—planted in late February, 1935 and harvested towards the end of May, 1935. The crop was irrigated and also received the beneficial effect of the early rain towards the end of April. The stand of the crop was fair. Although it was overtaken by the first rains in May, the bean crop was still good as the rain then was not yet continuous. Macoupin continued to be the outstanding variety in this culture. Table 8 presents the summary of this culture.

TABLE 8.—*Mean height of plants and grain yield of 10.5-meter row spaced at 50 cm. far apart, February to May, 1935 crop.*

Variety name	Average height per plant	Average yield in beans	Compute yield per hectare
	cm.	*gm.*	*kg.*
Cayuga	31.18±0.45	297.2± 7.74	566
Chinese	39.74±0.60	420.1±26.84	800
Dunfield	35.56±0.75	121.8± 8.86	803
Furisode	22.66±0.45	280.7±14.57	535
Hakubi	27.04±0.49	439.4±12.78	837
Illini	28.24±0.44	401.7± 1.59	765
Macoupin	41.38±0.60	668.0±30.25	1,272
Manchu	29.80±0.56	423.0± 8.86	806
Manchuria	30.76±0.79	280.7±14.56	535
Mandarin	32.14±0.71	239.3± 5.71	456
Midwest	29.86±0.64	318.4± 8.41	606
Otama-ao	19.24±0.35	112.7± 2.48	274
Otama-ao Str. 2	32.08±0.69	461.9± 7.64	880
Otama-ao Str. 3	34.84±0.56	487.1±19.97	928

Culture G.—While this was started late in the dry season (planting in April), it was considered a rainy-season culture because of early heavy rains that year. Three promising varieties were included in this test which was carried in semifield condition and replicated nine times. The plants were tall and the crop was very good although the harvest was partly spoiled by rain. Table 9 gives the results of this test.

TABLE 9.—*Comparative yields of three promising varieties of soybean, April to July, 1935 crop.*

Row number	Yield per row (20 5 meters long, spaced at 50 cm.)		
	Dunfield	Macoupin	Manchu
	Kg.	*Kg.*	*Kg.*
1	1.010	2.077	0.901
2	1.213	2.165	0.982
3	1.602	2.020	1.269
4	1.367	1.325	1.264
5	1.418	2.116	1.059
6	1.203	2.459	1.609
7	0.956	1.820	1.549
8	1.381	2.305	1.229
9	1.247	2.547	1.454
Mean	1.270 ±0.043	2.092 ±0.076	1.260 ±0.052
S. D.	0.19 ±0.030	0.34 ±0.054	0.23 ±0.036
C. V.	15.07 ±2.47	16.25 ±2.62	18.29 ±2.99
Average yield per hectare in kg.	1,239	2.041	1,229
Average yield per hectare in cavan	21.3	35.0	21.2
Average height of plant in cm.	62.44 ±0.92	86.86 ±0.58	65.38 ±0.77

Culture H.—This was a rainy-season culture of the three varieties tested in Culture G. The culture was conducted from the early part of June to the latter part of August, 1935. In this test, like the former the test, Macoupin was the best yielder. Table 10 presents the results of this study.

Culture I.—This culture was a dry-season planting. It was started in October, 1935, but unfortunately the planting was followed by strong and continuous rains that caused the decay of the seeds resulting in very low percentage of germination. While the growth of the few plants that survived was fair, it was deemed advisable not to include the results in this paper.

Culture J.—This culture was conducted from March to June, 1936. The varieties of less promise were included in this test. Table 11 presents the summary of the results obtained.

Culture K.—This was a rainy-season culture, planted in the early part of June and harvested in the early part of September, 1936. Macoupin was easily the best in performance in this test. Table 12 presents the result of this culture.

TABLE 10.—*Average yield of three promising varieties of soybean, June to August, 1935 crop.*

Row number	Grain yield of 5-meter row spaced 50 cm.		
	Dunfield	Macoupin	Manchu
	kg.	*kg.*	*kg.*
1	0.204	0.300	0.246
2	0.180	0.302	0.224
3	0.156	0.306	0.237
4	0.167	0.306	0.229
5	0.208	0.313	0.239
6		0.290	0.217
7		0.316	0.216
8		0.307	0.261
9		0.300	0.230
10		0.315	0.230
Mean	0.1793 ±0.0029	0.3055 ±0.0016	0.234 ±0.0066
S. D.	0.0105 ±0.0020	0.0076 ±0.0011	0.0293 ±0.0047
C. V.	5.856 ±1.1320	2.4877 ±0.3752	12.505 ±2.0178
Computed yield per hectare	732	1,222 932	

TABLE 11.—*Comparative yield of seven varieties of soybean, March to June, 1936 culture.*

Variety name	Average yield per 5-meter row	Computed yield per hectare
	kg.	*kg.*
Chinese	0.189 ±0.010	756
Furisode	0.174	696
Hakubi	0.263 ±0.014	1,052
Illini	0.191 ±0.005	764
Mandarin [1]	0.186	744
Midwest [1]	0.153	612
Otama-ao Str. 2	0.199 ±0.013	796

[1] Because of limited seed, only one replication was made; the rest were replicated 5 times.

TABLE 12.—*Comparative yield of six varieties of soybean, June to September, 1936 crop.*

Variety name	Average yield of 10.5-meter row	Comparative yield per hectare
	kg.	*kg.*
Chinese	0.455 ±0.010	367
Dunfield [1]	0.313 ±0.052	596
Illini	0.318 ±0.037	606
Macoupin	1.016 ±0.029	1,935
Manchu [1]	0.285 ±0.027	543
Otama-ao Str. 3 [1]	0.257 ±0.033	490

[1] The percentage of germination was rather low which accounted for the low yield.

Culture L.—This was a dry-season culture, the planting having beeng done during the early part of October, 1936. The germination, because of continuous rain soon after planting, was very low. The culture was continued just to save seeds for future plantings, but the data on yield were not determined any more.

Culture M.—A rainy-season culture. Of the 22 varieties planted, five completely failed to germinate; the rest only had a fair germination because of strong rain following planting. There were a few outstanding varieties with respect to growth and pod production e.g., Miss 28, E. B. Str. 3910, Head Green, and Mis 2 Behrum. It was also unfortunate that the date of maturity coincided with rainy days so that no accurate data on grain yield were obtained.

Culture N.—This was a late rainy-season culture, but the newly received seeds had to be planted to save them from losing their viability. Germination was only fair and so with growth. Using the Macoupin variety as the basis for comparison with respect to height of plants and pod bearing quality, Mamloxi and Mamredo were promising. No accurate data from this culture were obtained because of inclement weather towards maturity.

Table 12 was prepared so as to have a comparison of the average height of the plants when planted during the rainy season and during the dry season. Tables 13 and 14, on the other hand, present the comparative average yields of the different varieties when planted during the rainy season and when planted during the dry season.

DISCUSSION OF RESULTS

GENERAL BEHAVIOR OF THE PLANT

Owing to the fact that the soybean is a comparatively new crop in the Philippines, it may be advisable to include here a brief discussion of its local behaviour. Although the soybean is almost exclusively self-pollinated (9) it is rich in strains and varieties (4) which vary greatly in their habit of growth.

Habit of growth.—Of the over 40 varieties studied it was found that they vary in height, growth, and pod-bearing habit, of the plant, in size, shape, and color of seed, and in other char-

TABLE 13.—*Comparative height of soybean when grown at different times of the year.*

Variety name	Average height of plant		
	Early dry season (October to November planting)	Late dry season (February to March planting)	Rainy season (May to June planting)
	cm.	*cm.*	*cm.*
Akita	23.02±0.27	18.16±0.27	21.13±0.17
Cayuga		31.18±0.45	
Chinese		31.73±0.52	44.10±0.43
Dunfield		49.00±0.83	49.69±0.57
Furisode	26.56±0.32	21.45±0.42	31.96±0.39
Hakubi	32.80±0.41	24.91±0.39	38.25±0.53
Illini		28.24±0.44	56.01±0.29
Macoupin		64.12±0.59	70.02±0.54
Manchu		47.59±0.66	53.05±0.62
Manchuria		30.76±0.79	
Mandarin		32.14±0.71	51.94±0.49
Midwest	30.70±0.49	26.04±0.48	41.71±0.58
Otama-ao	25.30±0.04	17.98±0.26	27.49±0.17
Otama-ao Str. 2	36.52±0.46	30.63±0.57	46.23±0.64
Otama-ao Str. 3	39.99±0.51	34.84±0.56	46.09±0.61
Virginia	44.50±0.32	32.82±0.55	
Wilson Early Black	39.31±0.64	29.71±0.60	61.96±0.91

TABLE 14.—*Comparative bean yield per plant of soybean when grown at different times of the year.*

Variety name	Average yield of plant		
	Early dry season (October to November planting)	Late dry season (February to March planting)	Rainy season (May to June planting)
	cm.	*cm.*	*cm.*
Akita	5.01±0.11	4.88±0.13	4.14±0.09
Chinese		4.60±0.19	4.94±0.12
Dunfield			7.97±0.22
Furisode	3.93±0.19	6.21±0.21	6.12±0.13
Hakubi	9.04±0.28	7.67±0.19	8.40±0.24
Illini			7.17±1.10
Macoupin			12.25±0.23
Manchu			6.05±0.14
Mandarin			6.01±0.17
Midwest	6.66±0.28	7.22±0.17	8.87±0.31
Otama-ao	6.34±0.15	4.36±0.10	7.32±0.17
Otama-ao Str. 2	7.75±0.20	8.43±0.25	5.84±0.15
Otama-ao Str. 3	8.29±0.25		6.63±0.22
Virginia	6.50±0.15	5.16±0.11	
Wilson Early Black	6.53±0.21	5.73±0.16	8.23±0.19

TABLE 15.—*Comparative yield of soybean when grown at different times of the year.*

Variety name	Early dry season (October to November planting)	Late dry season (February to March planting)	Rainy season (May to June planting)
	kg.	*kg.*	*kg.*
Cayuga	(1)	566	(1)
Chinese	110	778	367
Dunfield	736	803	[2] 856
Furisode	88	616	(1)
Hakubi	353	945	(1)
Illini	724	765	606
Macoupin	743	1,272	1,733
Manchu	793	806	[2] 901
Manchuria	(1)	535	(1)
Mandarin	463	600	(1)
Midwest	434	609	(1)
Otama-ao	247	274	(1)
Otama-ao Str. 2	427	838	(1)
Otama-ao Str. 3	551	928	[2] 490

[1] Yield was determined by plant.
[2] Percentage of germination was rather low which accounted for the low yield.

TABLE 16.—*Average yield per plant of different varieties of soybean. (Summary of Tables 3 to 6 inclusive).*

Variety name	Average yield of beans per plant	Variety name	Average yield of beans per plant
	gm.		*gm.*
Akita	4.68±0.11	Mandarin	6.01±0.17
Chinese	4.94±0.12	Midwest	7.90±0.27
Dunfield	7.97±0.22	Otama-ao	6.01±0.14
Furisode	5.59±0.22	Otama-ao Str. 2	6.96±0.19
Hakubi	8.37±0.27	Otama-ao Str. 3	7.46±0.23
Illini	7.17±1.10	Virginia	5.83±0.13
Macoupin	12.25±0.23	Wilson Early Black	6.86±0.19
Manchu	6.05±0.14		

TABLE 17.—*Average yield of different varieties of soybean. (Summary of Tables 7 to 12 inclusive).*

Variety name	Average yield of beans per hectare		Variety name	Average yield of beans per hectare	
	Kilogram	Cavan [1]		Kilogram	Cavan [1]
Cayuga	566	9.9	Manchu	861	15.1
Chinese	583	10.2	Manchuria	535	9.4
Dunfield	821	14.4	Mandarin	555	9.7
Furisode	440	7.7	Midwest	551	9.7
Hakubi	747	13.1	Otama-ao	259	4.5
Illini	715	12.5	Otama-ao Str. 2	701	12.3
Macoupin	1,443	25.3	Otama-ao Str. 3	656	11.5

[1] One cavan of soybean weighs, in the average, 57 kilograms.

acters. The characters of the same variety vary according to the season of the year when planted, the condition of the soil, the source of seed, etc. Most of the varieties studied are erect with a well-defined main stem, with or without branches. In some varieties, the stems are elongated, more or less twining, and are suberect or even procumbent. In the bushy varieties, the internodes are generally short and the pods are more or less densely crowded; while in the tall varieties, the internodes are elongated and the pods are scattered (Plate 5). As a rule, plants grown during the rainy season attain very much greater height, and often produce more branches than those grown during the dry season (Plate 4, figs. 1 and 2).

Foliage.—The leaves are trifoliate and they vary greatly in shape, color, size, and in persistence. In practically all the varieties studied, the leaves begin to turn yellow as the pods reach the dough stage. At maturity the plant is practically naked.

Pubescence.—The soybean is hairy, and there is practically little variation in the extent of hairiness. The pubescence is either white (gray) or tawny.

Flowers.—The flowers which are tiny are borne in clusters on short axillary or terminal racemes. The color of the flower is either white or purple. It is during the flowering stage that the plant has the most rapid growth and development which may explain the uniform maturity of the pods of most varieties. Flowers begin to appear in from 20 to 70 days after planting.

Pods.—In most of the varieties studied, the pods are distinctly compressed, although there were a few cases where the pods were rather cylindrical. The size of the pods varies greatly. In most varieties, the number of seeds to the pod is 2 to 3, although occasionally 4 may be found. The pods are borne in clusters, and they may appear crowded or scattered depending upon the length of the internodes. The pods may be gray, straw-colored, tawny, or dark brown at maturity. Some varieties scatter their seeds easily, others do not.

Seed.—The seed varies greatly in size, shape, and color (Plate 6). The most common color is that of straw of varying shades. Black, chocolate, and green colors are also found. The average weight of one cavan of soybean seed is 57 kilograms.

The seed is rich in oil and protein; the protein content is about 36 per cent while the oil content is about 18 per cent (Table 18). This high oil content makes the seed very sensitive to too much moisture in the soil. When sowing is followed by a heavy

rain, the germination is poor and most of the seeds rot. In order to have a good germination, the soil should have an optimum moisture content, and the sowing should be done when there is no danger of heavy rain.

TABLE 18.—*Analysis of some locally grown soybean.*[1]

Variety name	Moisture	Ash	Ether extract	Protein	Crude fiber
	Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*
Cayuga	11.40	6.37	16.66	35.94	7.16
Chinese	13.27	6.32	16.65	34.19	8.74
Dunfield	14.36	5.72	22.28	32 25	6.06
Illini	11.85	5.92	18.29	36.19	6.10
Macoupin	13.45	5.85	20.86	33.00	7.01
Manchu	14.44	5.86	18.03	37.50	5.88
Manchuria	12.22	6.39	19.42	35.19	6.25
Mandarin	12.47	6.24	17.00	37.00	6.2C
Otama-ao Str. 2	12.03	6.22	16.17	37.38	7.05
Otama-ao Str. 3	13.34	6 04	16.47	39.09	6.20

[1] Analysis made by Chemistry Section, Bureau of Plant Industry.

Period of maturity.—The period of maturity varies with the variety and the season of the year when planted. The varieties tested vary in their maturity from 70 to 180 days after sowing. As a rule a variety requires longer time to mature when planted at the beginning of the rainy season. In general, earliness is correlated with the height of the plant, the tall varieties being late maturing.

In this connection, it may be mentioned that a prolonged rain at maturity is detrimental to the beans. They decay very easily when wet over a day at maturity.

THE FIRST INTRODUCTION

The first set of introduction, consisting of seven varieties, represented the materials tested in Cultures A, B, and C, which were made during the different seasons of the year. In Culture A, as seen in Table 3, the four best varieties in bean yield were Midwest, Hakubi, Wilson Early Black, and Furisode. The corresponding bean yields of these varieties were 10.43 ± 0.23, 9.77 ± 0.24, 8.32 ± 0.19, and 8.31 ± 0.13 grams per plant. In Culture B, the four best varieties with respect to bean yield were Hakubi, Otama-ao Str. 3, Otama-ao Str. 2, and Midwest. Their corresponding yields of beans were 9.04 ± 0.28, 8.29 ± 0.25, 7.75 ± 0.20, and 6.66 ± 0.28 grams per plant (Table 4). In Culture C, those found best in the first two cultures were

again the best, namely, Otama-ao Str. 2, Habuki, Midwest, and Furisode. Their yields in beans were 8.43 ± 0.25, 7.67 ± 0.19, 7.22 ± 0.17, and 6.21 ± 0.21 grams per plant respectively (Table 5). It is noteworthy to mention that among the first batch of introduction, Hakubi, Otama-ao Str. 2, Otama-ao Str. 3, and Midwest were the best in performance in the first three cultures made.

SECOND SET OF INTRODUCTION

The second set of introduction included six varieties and these were tested with the promising varieties found in the first set of introduction. In Culture D, the tests were made on a small scale and the determination of yield was done by plant as in Cultures A, B, and C. The stand of the new immigrants was very good (Plate I, fig. 1) and the heights of the new varieties varied from 44.10 ± 0.43 to 72.73 ± 0.51 centimeters. As seen in Table 6, the five best yielders were Macoupin, Dunfield, Midwest, Illini, and Hakubi. Midwest and Hakubi were among the four best in the first set of introduction. The average grain yields of these varieties were 12.25 ± 0.23, 7.97 ± 0.22, 7.30 ± 0.39, 7.17 ± 1.10, and 7.02 ± 0.37 grams per plant, respectively. Variety Macoupin was easily the outstanding leader in yield; it was also the tallest, having an average height of 72.73 ± 0.51 centimeters (Table 6).

In several tests (Cultures E, F, J, and K) where the area devoted to each variety was much greater than in the previous cultures, thus enabling the computation of the yield per hectare, the best varieties based on their ability to produce beans were Macoupin, Hakubi, Illini, Manchu, Dunfield, Otama-ao Str. 2, and Otama-ao Str. 3. The average computed bean yields were 1,317, 747, 715, 714, 712, and 658 kilograms per hectare respectively. Macoupin was easily the best with an average yield of 1,317 kilograms, or 23.1 cavans, per hectare.

In a two-year test of Macoupin, Manchu, and Dunfield (Tables 9 and 10) it was further shown that Macoupin was really superior in yield at the Central Experiment Station. The range in yield of this variety was from 1,222 kilograms (21.4 cavans) to 2,041 kilograms (35.0 cavans) per hectare. Manchu which was second in yield had an average yield of 1,080 kilograms (18.9 cavans) per hectare while Dunfield had an average yield of 985 kilograms, or 17.3 cavans, per hectare. In Southern Illinois where it is generally warmer than in the Central or Northern part of the state, Macoupin and Illini were among the best

five varieties; Macoupin gave an average yield of 26 bushels (29.9 cavans per ha.) while Illini had an average yield of 24 bushels (27.7 cavans per ha.) per acre(5).

In the culture where Macoupin gave an average yield of 35 cavans per hectare the average height of the plants was 86.86 ± 0.58 centimeters, while Manchu and Dunfield in the same culture gave an average height of 65.38 ± 0.77 and 62.44 ± 0.92 centimeters, respectively (Table 9). It seems apparent that the yield in grain is associated with the height of the plant. However, it may be stated in this connection that the height of the plant is a variable character of the soybean plant that is greatly affected by the climatic conditions prevailing during the growing season, as will be shown later.

HEIGHT OF PLANTS

While there has not been any critical study on the effect of climate on the height of the plants, the data on the average heights of plants when planted at different seasons of the year tend to show that the soybeans planted at the beginning of the rainy season were taller than those planted at the beginning of the dry season (October to November plantings). Those planted late in the dry season (February to March plantings) were still more dwarf than those planted at the beginning of the dry season. As typical example, Otama-ao Str. 2 had an average height of 36.52 ± 0.46 centimeters when planted in early dry season, 30.63 ± 0.57 centimeters when planted in late dry season, and 46.23 ± 0.17 centimeters when planted at the beginning of the rainy season (Table 13). The only variety which grew taller during the early dry season was Akita. This variety gave an average height during the early dry season planting of 23.02 ± 0.27 centimeters, 18.16 ± 0.27 centimeters during the late dry-season planting, and 21.13 ± 0.17 centimeters during the early dry-season planting. In this connection it may be remarked that there was no determination of the soil fertility of the different plots used in the cultures. The plots, however, were adjacent to each other and the soil was fairly uniform.

BEAN YIELD AS AFFECTED BY SEASON

In the same way as in the height of the plants, there was no critical study made on the effect of climate on the bean yield of the different varieties. The general trend of the yield was not as marked as the tendency of the height of the plants.

But even at that, it was evident that in the majority of the varieties tested the early rainy season and the late dry season plantings had the tendency to give greater yields than the early dry-season plantings. Macoupin is a typical example of this; its average yield during the early dry-season culture was 743 kilograms per hectare, 1,733 kilograms per hectare for the early rainy season, and 1,272 kilograms per hectare for the late dry season (Table 15). This behavior of the soybean plant makes the problem rather difficult for the reason that the plant grows better and produces a greater crop when the hazards of rain are great, and produces less crop when the conditions favorable for the production of beans of good quality are prevalent. Both the early rainy-season and late dry-season crops are subject to the mercy of rain and typhoon at maturity, so that the yield of a big crop of good quality is a matter of luck. On the other hand, the early dry-season crop, which generally gives beans of good quality produces low yield.

It is of interest to note in this connection that the soybean, as grown locally, seems to maintain its habit of development in Manchuria (its native habitat) and in other temperate countries where it is grown during the summer months (June to September). Fragmentary observations so far made seem to point out that long light duration rather than adequate moisture in the soil is the most important factor that affects the development and growth of the plant. A better understanding of the effects of these factors on the growth and development of the soybean plant will greatly help in the more important task of isolating some varieties and strains that are adapted to dry-season culture. For it is now evident that the effort in soybeen research should be directed towards the isolation or discovery of some varieties or strains for dry-season planting. Breeding may contribute greatly towards the solution of this problem.

PROMISING VARIETIES

Taking the average yields of the different varieties as criterion and without due regard to the season of planting, the most promising among the varieties that were tested for a period of two or more years were Macoupin, Dunfield, Midwest, Illini, Hakubi, Manchu, Otama-ao Str. 2, and Otama-ao Str. 3. These varieties have been and are being tested and cultured on a bigger scale at the Lipa Coffee-Citrus Experiment Station, Lipa, Batangas, and the results of these tests will be reported in a

separate paper. Suffice it to state in this connection that most of the above-mentioned varieties, together with a few newer introductions, have shown more encouraging performances.

As seen in Table 16, the average bean yield per plant of the varieties tested varied from 4.62 ± 0.11 to 12.25 ± 0.23 grams. Macoupin, Hakubi, Dunfield, Midwest, Otama-ao Str. 3, Illini, and Otama-ao Str. 2 were the seven best yielders in their descending order. Their corresponding yields were 12.25 ± 0.23, 8.37 ± 0.27, 7.97 ± 0.22, 7.90 ± 0.27, 7.46 ± 0.23, 7.12 ± 1.10, and 6.96 ± 0.19 grams per plant. Variety Macoupin was easily the best in grain yield.

In the plot tests where the yield of grains per hectare was computed, the range in yield was from 259 kilograms (4.5 cavans) to 1,443 kilograms (25.3 cavans) per hectare (Table 17). With the exception of Midwest, the seven best varieties based on the yield per plant were also the best in yield in these tests, variety Manchu taking the place of Midwest. In their descending order the best yielders were Macoupin, Manchu, Dunfield, Hakubi, Illini, Otama-ao Str. 2, and Otama-ao Str. 3 and their respective average yields were 25.3, 15.1, 14.4, 13.1, 12.5, 12.3, and 11.5 cavans per hectare. Again, Macoupin was easily the best in yield of beans (25.3 cavans per ha.). In a two-hectare planting of this variety made at the Davao Penal Colony last February, 1937, an average yield of 15 cavans of clean beans per hectare was obtained. This speaks very highly of the future of this variety.

RECENT INTRODUCTIONS

Because of the continuous rain that prevailed when the May-to-September, 1937 culture was maturing, no accurate data on yield were obtained. However, based on the stand of the different varieties (Plate 1, fig. 2) and on their pod-bearing characteristics, there were a number of new varieties that were considered very promising. Such varieties as Nanking and Yellow Biloxi Hybrid from the Hawaii Agricultural Experiment Station, Mis 2 Behrum, Mis 33 Dixi and Mis 28 E. B. Str. 3910 from India, Head Green from the Los Baños College of Agriculture, U. P., and Mamloxi from Mississippi may be included among the promising varieties. In stand, a number of the above-mentioned varieties, particularly Yellow Biloxi Hybrid, Mis 33 Dixi, Mis 28 E. B. Str. 3910, and Head Green looked superior to Macoupin and Manchu in grain production.

From the results thus presented in this study, one could readily see the potential possibilities of the soybean as a source of

grain food. This becomes more so when one considers the comparative ease and short duration required in the culture of the crop. But the most important thing about this crop is its multiple uses as a source of raw materials for some industrial arts like soap, varnish, paint, plastics, and other manufactures; as a soil renovator; as an animal feed; and as a human food. The soybean is an excellent source of protein; it contains from 32.25 to 39.09 per cent protein (Table 18). One cannot, therefore, escape the conclusion that this particular food crop would be invaluable in the amelioration of the Filipino diet. Soybean has done wonders with the Japanese soldiers; it, too, will have a great potential usefulness in our scheme of national defense.

SUMMARY OF CONCLUSIONS

This paper presents the results of a 4½-year acclimatization test on soybean involving 56 different varieties introduced from a number of experiment stations in the United States, Hawaii, India, Japan, China, Federated Malay States, and Ceylon. Fourteen separate cultures were made; seven, during the rainy season and another seven, during the dry season.

The results thus far obtained were ever encouraging. The average yields varied with the variety, ranging from a few cavans to over 25 cavans per hectare.

Cultures made during the rainy season produced taller and more branchy plants and gave greater yields of beans than the dry-season cultures. The dry-season plantings gave beans of good quality while the rainy-season cultures were subject to the hazards of rain and typhoon at maturity.

Of the varieties tested for a period of two or more years, seven varieties were considered promising for rainy-season culture. These varieties are Macoupin, Manchu, Dunfield, Hakubi, Illini, Otama-ao Str. 2, and Otama-ao Str. 3. Their average yields varied from 11.5 cavans to 25.3 cavans per hectare, with the first three as the best. There was, however, one great hazard in connection with the rainy-season cultures in that the crop was sometimes partially or totally destroyed if the maturity coincided with rainy days.

Cultures thus far made during the dry season did not give very encouraging results. It was evident, nevertheless, that the varieties which gave the heaviest yields in the rainy-season cultures were concurrently the best in the dry-season plantings.

Of the more recent introductions, nine varieties have shown great promise for rainy-season planting. These are Yellow

Biloxi Hybrid, Mis 33 Dixi, Mis 28 E. B. Str. 3910, Head Green, American Black, Nanking, Mis 2 Behrum, Mamloxi, and Kachin. Some of these varieties, particularly Yellow Biloxi Hybrid, Mis 33 Dixi, Mis 28 E. B. Str. 3910, Head Green, and Mamloxi, have even shown greater possibilities than the Macoupin.

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ILLUSTRATIONS

Plate 1

(*a*) First culture (rainy season) of five American varieties. *1*. Mandarin, *2*. Macoupin, *3*. Illini, *4*. Dunfield, and *5*. Manchu.
(*b*) 1937 rainy-season culture of newly introduced varieties from India.
(*c*) A rainy-season culture of three promising varieties. *1*. Manchu, *2*. Macoupin, and *3*. Dunfield.

Plate 2

Different soybean varieties at maturity showing characteristic pod formation. *1*. Otama-ao Str. 3, *2*. Yellow Biloxi Hybrid, *3*. Kingwa, *4*. Seaweed, *5*. Nanking, *6*. Nanksoy, *7*. Otama-ao, *8*. Furisode, *9*. Midwest, *10*. Hakubi, *11*. Otama-ao Str. 2.

Plate 3

Different soybean varieties at maturity showing characteristic pod formation. *1*. Mis 28 E. B. Str. 3910, *2*. Head Green, *3*. Mis 33 Dixi, *4*. Mandarin, *5*. Chinese, *6*. Illini, *7*. Manchu, *8*. Dunfield, *9*. Macoupin.

Plate 4

Soybean varieties showing characteristic pod formation. *1* and *2* show two varieties when planted at different times of the year: *1-a*. Manchu (rainy season). *1-b*. Manchu (dry season). *2-a*. Macoupin (rainy season). *2-b*. Macoupin (dry season). *3*. Kachin. *4*. Mis 2 Behrum, and *5*. Yelow small.

Plate 5

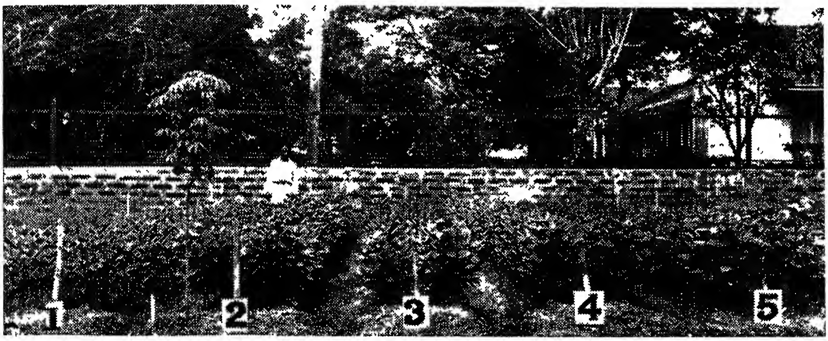
Varieties of soybean showing different mode of growth, branching, and pod formation. *1*. Dwarf compact, *2*. medium compact, *3*. single stem densely podded, *4*. branched stiffly stemmed with compact pod formation, *5*. finely stemmed with compact pod formation, *6*. stiffly stemmed, sparsely podded, *7*. finely stemmed, sparsely podded.

Plate 6

Grains of different varieties of soybean showing their relative size and shape.

1. American Black
2. Ami
3. Cayuga
4. Chinese
5. Dunfield
6. Furisode
7. Hakubi
8. Head Green
9. Illini
10. Kachin
11. Kingwa
12. Macoupin

13. Manchu
14. Manchuria
15. Manchuria Type 13-177
16. Mandarin
17. Mandell
18. Mamloxi
19. Mamredo
20. Midwest
21. Mis 2 Behrum
22. Miss 28 E. B. Str. 3910
23. Miss 33 Dixi
24. Nanking
25. Nanksoy
26. Otama-ao
27. Otama-ao Str. 2
28. Otama-ao Str. 3
29. Penagype
30. Scioto
31. Seaweed
32. Type 117
33. Type 65379
34. Yellow Biloxi Hybrid
35. Yellow Small.



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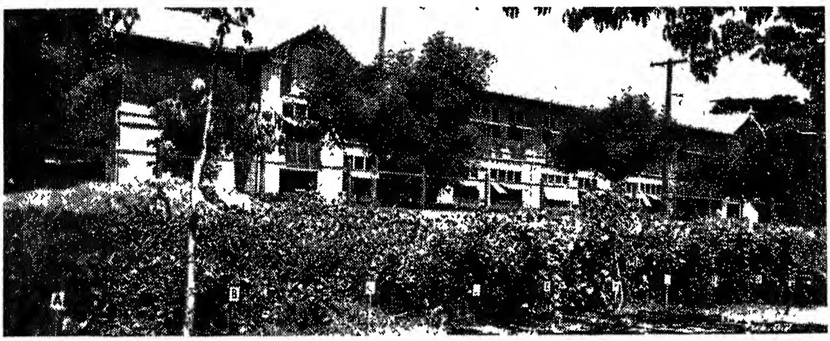

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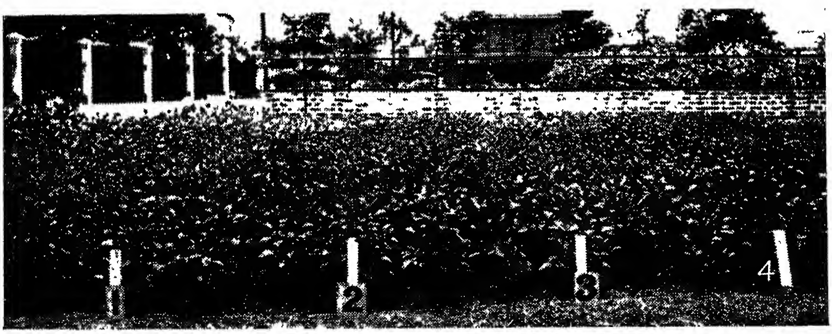

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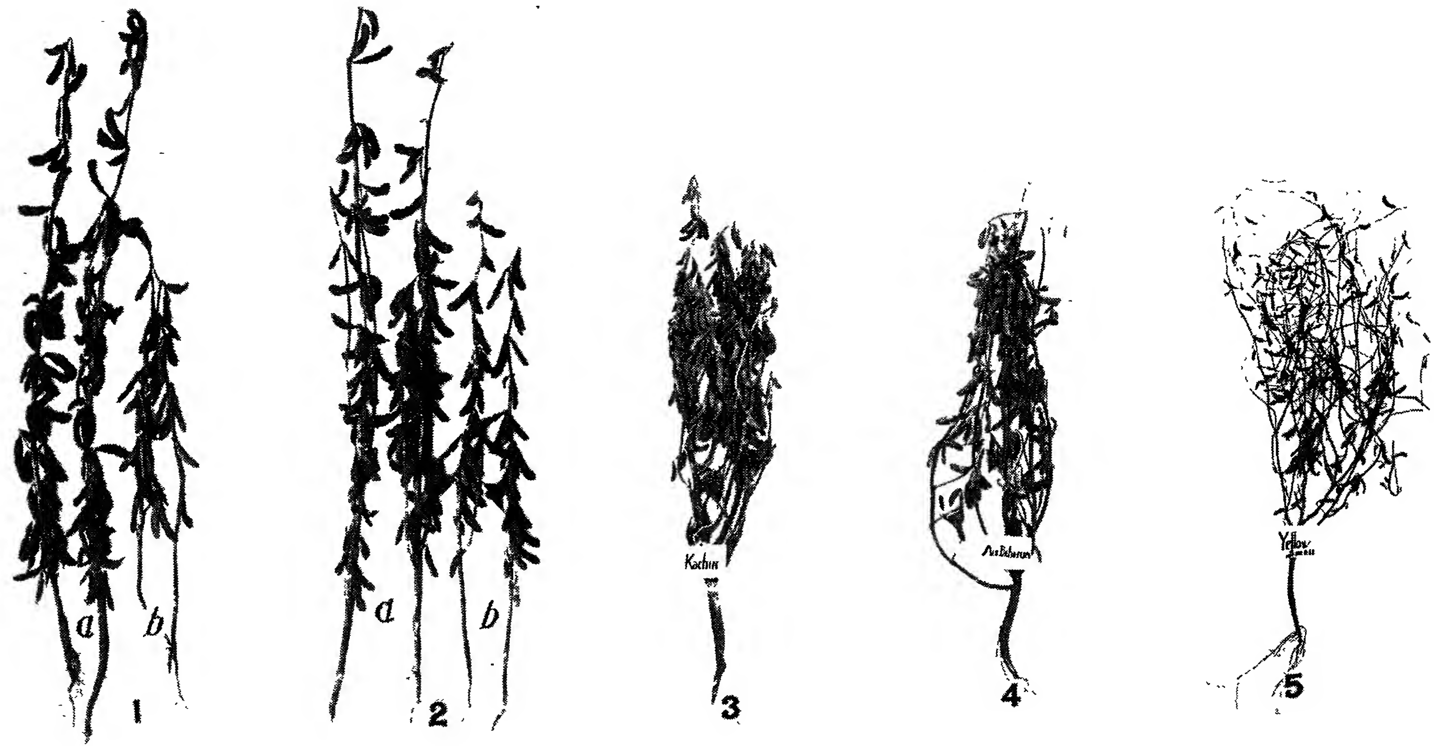
PLATE 1.

PLATE 2.

PLATE 3.



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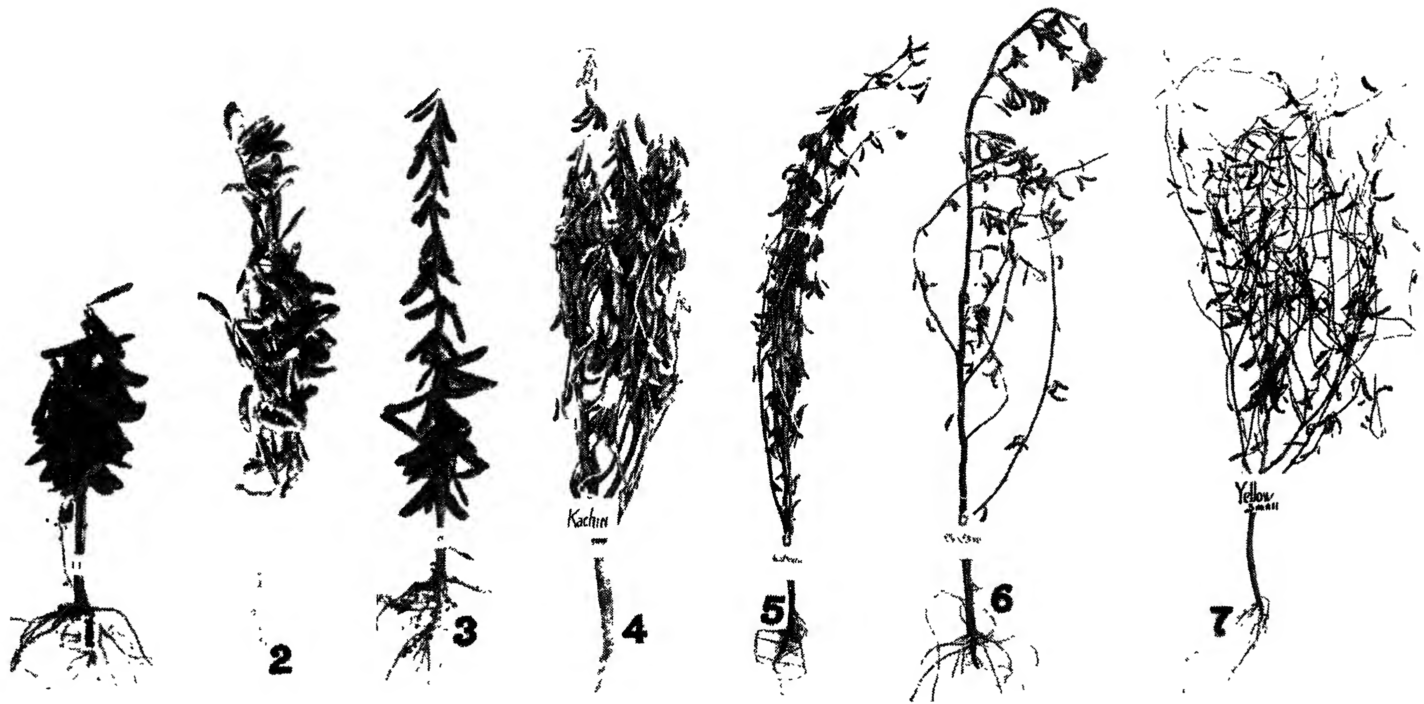

PLATE 5.

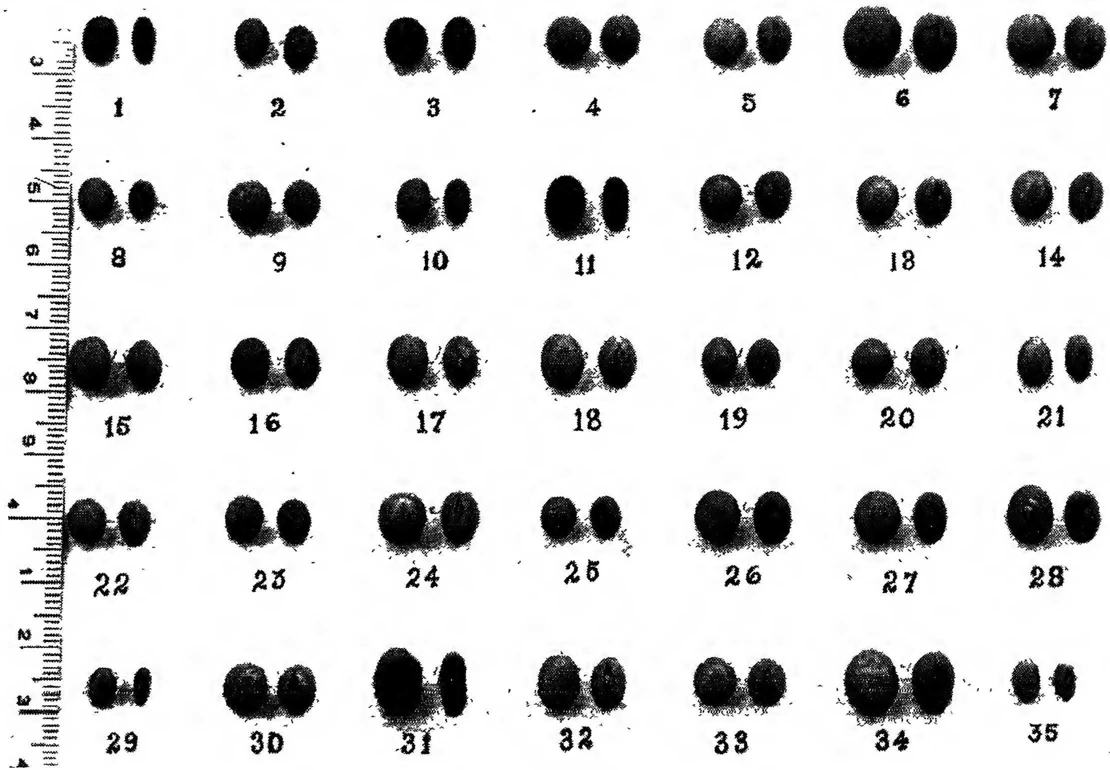
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PLATE 6.

STUDIES ON THE SALT REQUIREMENT OF TOBACCO

By Fernando de Peralta and Domingo B. Paguirigan

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Manila

SEVEN PLATES AND ONE TEXT FIGURE

A good understanding of the salt requirement of the tobacco plant helps in effecting a profitable application of fertilizers in tobacco fields which are fast depleting in soil fertility. Also, to be able to recognize the symptoms manifested by the tobacco plant when growing in a medium deficient in any salt or nutrient essential to its normal development, is of considerable practical importance. To attain these objectives, the method of growing plants in "sand and solution culture" was employed in order to make it possible to control the actual supply of nutrients, available to plants, which is virtually impossible to follow in soil-solution films.

REVIEW OF LITERATURE

This paper does not attempt to review the entire literature on the subject but rather to refer only to outstanding contributions dealing directly on the growth behavior of the tobacco plant.

Lieu(2) employed eleven solution mixtures of Type I as outlined by the Division of Biology and Agriculture, National Research Council of the United States[1] and found that no one particular solution could be selected to indicate a fertilizer formula for tobacco, since none of them supported the tobacco to maturity. In his studies he described blackening of petiole of the leaf just emerging from the bud and the subsequent killing of the terminal bud. The solutions used were made up on the basis of a complete nutrient solution prepared from the following salts; namely, KH_2PO_4, $Ca(NO_3)_2$, $MgSO_4$, and trace of iron.

McMurtrey, Jr.(4) succeeded in growing tobacco to maturity in connection with his studies on distinctive effects of the defi-

[1] Livingston, B. E. A plan for coöperative research on the salt requirements of representative agricultural crops. Second edition (1919), Baltimore.

ciency of certain essential elements on the growth of tobacco plants in solution cultures. He employed $Ca(NO_3)_2$, KNO_3, KH_2PO_4, $Mg(NO_3)_2$, NH_4Cl, and iron citrate. In addition to these chemicals added traces of H_3BO_3 and $Mn(C_2H_3O_2)_2$. These two substances were not found in Liu's solution mixture.

MATERIALS, METHODS, AND RESULTS

It is the intention here to discuss only in a broad and general manner the methods of procedure followed in this study. The detailed discussions for "sand and solution culture" work can be obtained by consulting the work of Livingston, Craker, and Kelerman (3).

THE PLANTS

The plants were grown from seeds of tobacco, variety *Ilagan Sumatra* germinated in quartz sand.[1] Sixteen days after sprouting, uniform seedlings were selected and planted in wide-mouthed one-liter bottles filled with complete nutrient solution, or when the bottles were filled with quartz sand, the seedlings were watered daily with complete culture solution mixture. The extra solution in the container was drained off by means of a little opening located at the bottom of the bottle as shown in Figure 1.

Five sets of cultures were made in this study and are designated as *Trial 1, Trial 2, Trial 3, Trial 4,* and *Trial 5.* The plants were grown in the greenhouse of the Tobacco Research Section and each culture was made in duplicate. Before the plants were harvested they were first photographed, after which the roots, stems, and leaves were harvested separately and dried in Freas electric oven to a constant weight. The data obtained from the different trials are recorded in separate tables which will be considered separately.

Trial 1.—The cultures in this trial were made from December 14, 1934 to April 11, 1935. Three types of culture solutions were employed (Table 1) and they differed principally as regards the form of nitrogen present in the culture medium. Type I contained nitrate nitrogen; Type II, the ammonia form; and Type III, both the nitrate and ammonia form of nitrogen. Following Schreiner and Skinner triangular scheme, (5) seven different culture solutions located at strategic points within the triangle were selected for study. These culture solutions varied

[1] Furnished by Ottawa Silica Company, Ottawa, Illinois.

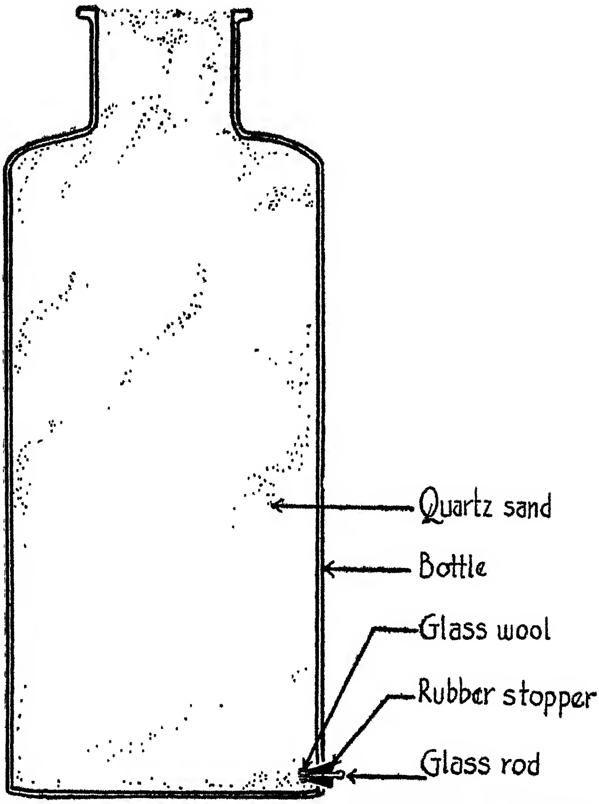

FIG. 1. Longitudinal section of a 1-liter bottle employed in sand-culture work.

in salt proportion, but all had the same total concentration (gram-molecule per liter of all salts). The component parts of the different culture media tried are shown in Table 1.

The plants grown in the three types of culture solutions were photographed twice. The first was taken when the plants were 77 days old since transplanting. Forty-one days later another picture of the same plants was taken before they were harvested (Plate 1-b). The results obtained are shown in Table 2.

The symptoms observed by Liu, such as the blackening of the stem of the leaf just emerging from the bud and the subsequent killing of the terminal bud of the plant were also noted in all the plants grown in the different culture solutions tried in Trial 1. This abnormal growth of the tobacco plants was more apparent in the vigorously growing plants than in the short and stunted ones (Plate 2).

TABLE 1.—*Proportion and concentration of the salts used in Trial 1 in each culture medium. The concentration is in gram-molecule.*

TYPE I

Culture	Salt proportion			
	KH_2PO_4	$Ca(NO_3)_2$	$MgSO_4$	Total concentration
No. 1	.0002	.0010	.0008	.002
No. 2	0004	.0004	.0012	.002
No. 3	.0004	.0012	.0004	.002
No. 4	.0006	.0008	.0006	.002
No. 5	.0010	.0002	.0008	.002
No. 6	.0010	.0008	.0002	.002
No. 7	.0016	.0002	.0002	.002

TYPE II

Culture	Salt proportion				
	KH_2PO_4	$(NH_4)SO_4$	$Ca(H_2PO_4)_2$	$MgSO_4$	Total concentration
No. 1	.00025	.00075	.00075	.00025	.002
No. 2	.00025	.00075	.00025	.00075	.002
No. 3	.00025	.00025	.00075	.00075	.002
No. 4	.00075	.00075	.00025	.00025	.002
No. 5	.00075	.00025	.00075	.00025	.002
No. 6	.00075	.00025	.00025	.00075	.002

TYPE III

Culture	Salt proportion				
	KH_2PO_4	$(NH_4)_2SO_4$	$Ca(NO_3)_2$	$MgSO_4$	Total concentration
No. 1	.00025	.00075	.00075	.00025	.002
No. 2	.00025	.00075	.00025	.00075	.002
No. 3	.00025	.00025	.00075	.00075	.002
No. 4	.00075	.00075	.00025	.00025	.002
No. 5	.00075	.00025	.00075	.00025	.002
No. 6	.00075	.00025	.00025	.00075	.002
No. 7	.00025	.000375	.000375	.0010	.002

NOTE:—$FePO_4$ was prepared as recommended by Livingston and 2.5 c.c of the suspension was added to every 1,000 c.c. of culture solution mixture.

Trial 2.—Culture solution No. 3 of Type I, *Trial 1* produced the tallest tobacco plant, but upon reaching the age of 97 days the young leaves making up the bud showed abnormal growth which finally developed to cause the death of the terminal bud of the plant.

TABLE 2.—*Data from the cultures in Trial 1 obtained at the time of harvest.*

TYPE I

Culture	Culture bottle	Dry weight				General appearance of plant
		Roots	Stem	Leaves	Whole plant	
		gm.	*gm.*	*gm.*	*gm.*	
No. 1	1-a	1.180	1.480	2.047	4.707	Plant, vigorous. Leaves, green. Terminal bud, abnormal.
	1-b	1.215	1.695	2.085	4.995	
	Average	1.1975	1.5875	2.066	4.851	
No 2	2-a	0.605	0.665	0.960	2.230	Do.
	2-b	0.660	0.575	0.940	2.175	
	Average	0.6325	0.620	0.950	2.2025	
No. 3	3-a	1.555	2.395	2.745	6.695	Do.
	3-b	1.120	2.215	2.395	5.730	
	Average	1.3375	2.305	2.570	6.2125	
No. 4	4-a	0.980	1.510	1.650	4.140	Do.
	4-b	0.985	1.290	1.680	3.955	
	Average	0.9825	1.400	1.665	4.0475	
No. 5	5-a	0.240	0.175	0.515	0.930	Growth, stunted. Leaves, pale green.
	5-b	0.285	0.185	0.450	0.920	
	Average	0.2625	0.180	0.4825	0.925	
No. 6	6-a	1.100	1.435	1.945	4.480	Plant, vigorous. Leaves, green. Terminal bud, abnormal.
	6-b	0.940	1.290	1.755	3.985	
	Average	1.020	1.3625	1.850	4.2325	
No. 7	7-a	0.480	0.145	0.470	1.095	Growth, stunted. Leaves pale green.
	7-b	0.395	0.125	0.480	1.000	
	Average	0.4375	0.135	0.475	1.0425	

Recent literature on the subject points to the importance of boron present in the nutrient medium. This element was not added in the culture solution mixture employed in *Trial 1*. Employing the sand and solution culture methods of growing tobacco, six culture bottles of 1-liter capacity were prepared. These bottles were filled with culture solution No. 3 of Type I (Table 1) but to two of them, in addition to the solution mixture employed, boric acid (H_3BO_3) at the rate of 0.5 cc p.p.m. was added. The bottles were then provided with cork stoppers. A hole, one centimeter in diameter, was bored to every cork stopper. Through the holes, a tobacco seedling was carefully inserted, and to keep the seedling in position so that the roots were

TABLE 2.—*Data from the cultures in Trial 1 obtained at the time of harvest*—Continued.

TYPE II

Culture	Culture bottle	Dry weight				General appearance of plant
		Roots	Stem	Leaves	Whole plant	
		gm.	*gm.*	*gm.*	*gm.*	
No. 1	1-a	1.165	0.060	0.350	0.575	Plant, poor. Growth, stunted. Leaves, green.
	1-b	0.155	0.045	0.195	0.395	
	Average	0.160	0.0525	0.2725	0.485	
No. 2	2-a	0.040	0.020	0.095	0.155	Do.
	2-b	0.045	0.015	0.085	0.135	
	Average	0.0425	0.0175	0.090	0.145	
No. 3	3-a	0.210	0.114	0.330	0.654	Do.
	3-b	0.195	0.105	0.305	0.605	
	Average	0 2025	0.1095	0.3175	0.6295	
No. 4	4-a	0.030	0.025	0.085	0.140	Do.
	4-b	0.050	0.010	0.150	0.210	
	Average	0.040	0.0175	0.1175	0.175	
No. 5	5-a	0.175	0.070	0.255	0.500	Do.
	5-b	0.155	0.060	0.205	0.420	
	Average	0.165	0.065	0.230	0.460	
No. 6	6-a	0.193	0.085	0.245	0.523	Do.
	6-b	0.165	0.060	0.240	0.465	
	Average	0.179	0.0725	0.2425	0.494	

fully immersed in the solution, non-absorbent cotton was placed around the stem of the seedling. The amount of water lost through transpiration was replaced by adding distilled water. The plants were photographed when they were 103 days old (Plate 3) and described as shown in Table 3.

Seedlings of approximately the same size were planted in another four culture bottles filled with quartz sand. The plants were watered daily with culture solution No. 3 of Type I (Table 1). The extra solution was drained off through a small opening made at the bottom of the culture vessel. When the plants were 75 days old, the young leaves of the four plants making up the bud showed symptoms of abnormal growth as shown by the arrow in Plate 4. At this time 0.5 cc, p.p.m. of boric acid (H_3BO_3) was introduced into two of the culture bottles

TABLE 2.—*Data from the cultures in Trial 1 obtained at the time of harvest*—Continued.

TYPE III

Culture	Culture bottle	Dry weight				General appearance of plant
		Roots	Stem	Leaves	Whole plant	
		gm.	*gm.*	*gm.*	*gm.*	
No. 1	1-a	0.565	0.687	1.015	2.267	Plant, fair. Leaves, green Terminal bud, abnormal.
	1-b	0.557	0.780	1.092	2.429	
	Average	0.561	0.7335	1.0535	2.348	
No. 2	2-a	0.420	0.370	0.505	1.295	Do.
	2-b	0.405	0.385	0.575	1.365	
	Average	0.4125	0.3775	0.540	1.330	
No. 3	3-a	0.735	1.115	1.545	3.395	Growth, vigorous. Leaves green. Terminal bud, abnormal.
	3-b	0.605	0.995	1.420	3.020	
	Average	0.670	1.055	1.4825	3.2075	
No. 4	4-a	0.325	0.195	0.475	0.995	Plant, poor. Leaves, pale green. Growth, stunted.
	4-b	0.330	0.190	0.560	1.080	
	Average	0.3275	0.1925	0.5175	1.0375	
No. 5	5-a	0.525	0.720	1.350	2.595	Plant, fair. Leaves, green. Terminal bud, abnormal.
	5-b	0.505	0.690	1.250	2.445	
	Average	0.515	0.705	1.300	2.520	
No. 6	6-a	0.385	0.313	0.710	1.408	Plant, poor. Leaves, pale yellow. Growth, stunted.
	6-b	0.375	0.260	0.690	1.265	
	Average	0.380	0.2865	0.700	1.3365	
No. 7	7-a	0.585	0.740	1.050	2.375	Plant, fair. Leaves, green. Terminal bud, abnormal.
	7-b	0.610	0.760	1.210	2.580	
	Average	0.5975	0.750	1.130	2.4775	

(back, Plate 4), leaving the other two plants (front, Plate 4) continuously watered with culture solution No. 3 of Type I. After a period of four weeks from the date of the introduction of H_3BO_3 the plants were photographed (Plate 4) and described as presented in Table 4.

Trial 3.—The addition of boric acid to culture solution No. 3 of Type I proved necessary for the growth of the tobacco plants (Tables 3 and 4). What form of nitrogen does the tobacco plant prefer in a complete nutrient medium? This was the subject of study in *Trial 3.* Nine 1-liter culture bottles

TABLE 3.—*Effect upon the external appearance and growth of tobacco plant (water culture) of adding H_3BO_3 to a complete culture nutrient solution.*

Date of observation	Complete nutrient solution with H_3BO_3	Complete nutrient solution without H_3BO_3
January 3, 1936	Plant, vigorous Leaves, green.	Plant, vigorous. Leaves, green.
February 10, 1936	Plant, normal. Leaves, green.	Plant, normal. Young leaves showed sign of crowding. Color of young leaves, light green.
March 10, 1936	Plant, normal. Leaves, green. Margin of lamina, smooth. Leaf-tips, green.	Plant, green. Bud, distorted. Young leaves, light green with a peculiar cupping downward. Base of petioles, pale yellow.
March 24, 1936	do	Growth, abnormal. Matured leaves, light yellow. Young and medium-aged leaves, light green and thickened. Suckers developed, but all buds, dead.
April 10, 1936	Plant, normal. Leaves, green. Margin of lamina, smooth. Leaf-tips, green. Roots normal, white.	Growth, abnormal. Matured leaves, yellow. Medium-aged leaves, pale yellow. Young leaves, light green but lamina thickened, not smooth. Terminal bud, dead. Buds of suckers, dead. Leaves of suckers, pale yellow and buds distorted.

TABLE 4.—*Effect upon the external appearance and growth of tobacco plant (sand culture) of adding H_3BO_3 to a complete culture nutrient solution.*

Date of observation and treatment	General appearance of plant
January 2, 1936: All plants watered with culture solution No. 3, Type 1.	All plants, normal. Growth, vigorous. Leaves, green.
January 2 to February 10, 1936: All plants watered with culture solution No. 3, Type I.	All plants appeared normal. Young leaves showed sign of crowding. Color of young leaves, light green.
February 10 to March 2, 1936: All plants watered with culture solution No. 3, Type I.	All plants showed abnormal bud growth. Youngest leaf, pale green. Base of petioles of leaves making up bud, pale yellow. Buds, ceased to grow with a somewhat drowned appearance, Plate 4.
March 2–30, 1936: (a) Two plants watered with culture solution No. 3, Type I.	Terminal buds, dead (Front Plate 1). Leaves, thickened, corrugated, and cupped. Curled downward. Suckers, developed but buds dead.
March 2–30, 1936: (b) Two plants watered with culture solution No. 3, Type I plus O .5 cc. p. p. m. of H_3BO_3.	Normal leaves developed following leaf with distorted leaf-tip (tip of leaf pointed by arrow, Plate 4). Growth of newly developed leaves, normal. Leaves, smooth and green.

filled with pure sand were prepared. The sand used was first washed with a weak solution of formaldehyde and then washed thoroughly with distilled water. Later the sand was dried in Freas electric oven for 3 days at a constant temperature of 100°C. The culture bottles were numbered consecutively from one to nine. Uniform tobacco seedlings (16 days old) were planted to the first six culture bottles, and the last three bottles were not planted (Control). The culture bottles were watered with culture solution as shown in Table 5 and the mouth of the bottles were plugged with cotton (Plate 5). Extra solution was drained off through a little opening at the bottom of the bottle.

TABLE 5.—*Proportion and concentration of culture solutions used in Trial 3. The concentration is in gram-molecule.*

Culture solution number	Salt proportion					
	KH_2PO_4	$(NH_4)_2SO_4$	$Ca(NO_3)_2$	$Ca(H_2PO_4)_2$	$MgSO_4$	Total concentration
1	.0004	.0012		.0002	.0004	.0022
2	.0004	.0012		.0002	.0004	.0022
3	.0004	.0012		.0002	.0004	.0022
4	.0004		.0012	.0002	.0004	.0022
5	.0004		.0012	.0002	.0004	.0022
6	.0004		.0012	.0002	.0004	.0022
7	.0004	.0012		.0002	.0004	.0022
8	.0004	.0012		.0002	.0004	.0022
9	.0004	.0012		.0002	.0004	.0022

NOTE.—2.5 cc of $FePO_4$ was added to every 1,000 cc of culture solution. Boric acid was added to every culture solution at the rate of 0.5 cc, p.p.m.

At weekly intervals, during a period of one month, when the plants were already well developed, qualitative nitrate determination [1] was undertaken. Samples of the solution to be tested were drained through small openings located at the bottom of each of the culture bottles and the liquids obtained were immediately tested for nitrate. The results are presented in Table 6. The plants were photographed upon reaching maturity (Plate 5).

[1] Nitrate determination was conducted by Mr. Severino Etorma of the Chemistry Section of the Bureau of Plant Industry.

TABLE 6.—*Description of plants and results of nitrate determination from drainage obtained from culture bottles watered with culture solution as shown in Table 5.*

Drainage from culture solution number	Nitrate test Absent (—) Present (+)	General appearance of plant
1	—	Plant, green. Growth poor, stunted.
2	—	Do.
3	—	Do.
4	+	Plant, normal. Growth, vigorous. Leaves, green. Flowered.
5	+	Do.
6	+	Plant, normal. Growth, vigorous.
7	—	Control (No plant).
8	—	Do.
9	—	Do.

Trial 4.—Does the presence of $Ca(H_2PO_4)_2$ in a complete culture solution as shown in Table 5 make the growth of the tobacco plant more vigorous than when without it? This inquiry was the subject of study in *Trial 4.* Four culture bottles of 1-liter capacity were filled with pure sand and planted with uniformly selected tobacco seedlings. The plants were watered regularly with culture solutions as shown in Table 7. Before the leaves were harvested the plants were photographed first (Plate 6). The results obtained are presented in Table 8.

TABLE 7.—*Proportion and concentration of the salts used in Trial 4. The concentration is in gram-molecule.*

Culture number	KH_2PO_4	$Ca(NO_3)_2$	$Ca(H_2PO_4)_2$	$MgSO_4$	Total concentration
1	.0004	.0012	.0002	.0004	.0022
2	.00044	.00132		.00044	.0022

$FePO_4$—2.5 cc per liter of solution
H_3BO_3—0.5 cc, p.p.m.

TABLE 8.—*Harvest data obtained from tobacco plants fed with culture solutions as shown in Table 7 (Trial 4). The figures are averages of harvests obtained from 2 plants.*

Criteria considered	Culture No. 1	Culture No. 2
Height of plant, cm.	67.5	63.0
Circumference of stem at 10 cm. from base, cm.	1.2	1.0
Number of dry leaves	10.0	8.0
Number of yellow leaves	1.0	1.0
Number of green leaves	14.0	13.0
Total leaf products of green leaves, sq. cm.	1,729.5	1,468.1
Dry weight of roots, gm.	1.8	1.4
Dry weight of stems, gm.	4.22	3.89
Dry weight of all leaves, gm.	5.01	4.25

Trial 5.—The presence of $Ca(H_2PO_4)_2$ in a complete culture solution having a total concentration of 0.0022 molar (all salts taken together) as shown in Table 7 and watered to tobacco plants grown under controlled condition produced bigger plants. What is the optimum molar concentration of the salt mixtures best for the growth of the tobacco plant? This question was the object of study of *Trial 5*. Twelve culture bottles of 1-liter capacity were prepared as usual. They were filled with quartz sand and planted to tobacco seedlings after sixteen days from sprouting. The plants were watered regularly with culture solutions as shown in Table 9. Every culture solution mixture was run in duplicate and tried twice at different times of the year. When the plans were 105 days old from sowing, they were photographed (Plate 7) and later harvested. The data are presented in Table 10.

TABLE 9.—*Culture solutions employed for Trial 5. The ratio of the molar proportion used in Trial 4 was kept constant, but the total concentration of all the solts taken together was made variable. The concentration is in gram-molecule.*

Total concentration	Molecular proportion			
	KH_2PO_4	$Ca(NO_3)_2$	$Ca(H_2PO_4$	$MgSO_4$
.00055	.0001	.0003	.00005	.0001
.0022	.0004	.0012	.0002	.0004
.0088	.0016	.0048	.0008	.0016
.0132	.0024	.0072	.0012	.0024
.0220	.0040	.0120	.0020	.0040

$FePO_4$—2.5 cc per liter of solution
H_3BO_3—0.5 cc, p.p.m.

DISCUSSION OF RESULTS

The external appearance of the plants was used as the basis of comparison for the relative nutritive value of the different culture media employed in this study. The other criteria, like height, dry weights, and other quantitative characters, are here considered as supplementary only. The reason for this is that two plants may appear alike in dry weights or in heights, but may differ markedly in the presence or absence of some physiological abnormalities, like drying of leaf tips and buds and leaf coloration.

TABLE 10.—*Harvest data obtained from tobacco plants watered with culture solution mixtures as shown in Table 9 (Trial 5). The figures are averages of results obtained from two plants.*

	Total concentration (gram-molecule) of culture solution (Table 9)				
Criteria considered	.00055	.0022	.0088	.0132	.022
Height, cm.	32.2	86 5	92.1	96.2	65.2
Diameter of stem, mm.	4 0	6.0	8.0	8.0	5.5
Number of leaves	8 0	13 0	15.0	15.5	12.5
Leaf products of all leaves, sq. cm	576.5	2,366 0	2 505.0	2,730.0	1,820.0
Dry weight of stem, gm	1.41	5.89	6.02	6.81	4.55
Dry weight of roots, gm.	.60	2.52	2.75	3.0	2.0
Dry weight of leaves, gm	1 72	7 21	7.95	8 38	5.59
Dry weight of whole plants, g.	3.73	15.65	16.72	18.19	12.14
Color of fresh leaves	Pale green	Normal green	Normal green	Normal green	Dark green

GROWTH DEVELOPMENT OF TOBACCO PLANT IN DIFFERENT NUTRIENT MEDIA

The tobacco plants fed with culture solution mixtures of Type I were generally better developed than those grown in Types II and III (Plate 1-a and Table 2), yet not a single plant in Type I grew normally toward the later stage of growth development. When the plants were 90 days old (Plate 1-b), especially those in culture solutions Nos. 1, 2, 3, and 4 of Type I and culture solutions Nos. 1, 3, 5, and 7 of Type III, they had distorted terminal buds. The young leaves making up the bud first showed manifestation of a light green color. Later the base of the petioles changed from pale green to pale yellow. This was followed by the death of the terminal bud. The leaves already produced continued to grow. The lamina thickened and curled downward. Generally the youngest leaf, if it develops at all shows a missing tip and a cut-out outline of the margin. This bud abnormality was not visible in the poor and stunted plants, such as those grown in the different culture mixtures of Type II, but was most apparent in plants grown in culture solution No. 3 of Type I. However, these plants were the biggest and best developed in the whole set (Plate 2).

The death of the terminal buds of the tobacco plants may be attributed to three causes, namely, (1) physical injury such as insect bites, (2) fungus infection, and (3) the nutrient medium in which the plants were grown. The first two possible causes of the death of the buds were eliminated on the basis of the find-

ing of the Chief of the Pathology Section, Bureau of Plant Industry, that no physical injury nor pathogen was observed on dead buds placed in an agar culture medium. It was very probable, therefore, that the death of the buds of the tobacco plants was due to the absence of a certain element or elements in the nutrient medium necessary for continuous normal growth of the tobacco plant. None of the three types of culture solution mixture employed in *Trial 1* was found satisfactory to growing normal tobacco plant to maturity.

The NH_4-free culture, Type I.—At the early stage of growth development the tobacco plants, which were supplied with nitrate-nitrogen, grew vigorously. The leaves were normal and green and the plants were the best developed in the entire set; but at a later stage of growth when the plants were 90 days old, the young leaves making up the bud showed manifestation of yellowing which was finally followed by the death of the terminal bud. This bud malady was most noticeable among the vigorously growing plants. The other plants in the NH_4-free culture (Table 1) also exhibited varying degrees of bud abnormalities (Plate 2). And as usual, the smallest developed plants showed no visible bud abnormality. The culture solution that produced the best developed plant, although exhibiting the most apparent bud abnormality, contained 0.0004 M KH_3PO_4, 0.0012 M $Ca(NO_3)_2.4H_2O$, .0004 M $MgSO_4.7H_2O$, and 2.5 cc of $FePO_4$. At the age of 90 days, the plant fed with this salt mixture had a total average dry weight of 6.21 grams per plant.

The NO_3-free cultures, Type II.—Plants supplied with ammonia-nitrogen showed early manifestation of stunted growth. There was no visible bud abnormality but the growth of the plant was decidedly stunted. This was attributed to the absence of nitrate-nitrogen in the culture medium (Table 1). The average dry weights of plants grown in culture medium supplied with ammonia-nitrogen were all lighter than those which were supplied with nitrate-nitrogen (Table 2, Type II). The biggest plant in the former had an average total dry weight of only 0.62 gram, while in the latter, the best plant had an average dry weight of 6.21 grams per plant.

Cultures containing NO_3-and NH_4-nitrogen, Type III.—The plants fed with culture solution containing both the nitrate- and ammonia-nitrogen were found better developed than those plants fed with ammonia-nitrogen only (Table 1 and Plate 1). But the best developed plants in this group also showed distorted terminal buds similar to those observed in Type I (the NH_4-free

cultures). The bud abnormality was always most apparent in the vigorously growing plants. The best plant in this group produced an average total dry weight per plant of 3.20 grams which was approximately one-half as heavy as the heaviest plant supplied with nitrate-nitrogen only.

Boric acid added to NH_4-free culture solution.—Tobacco plants grew vigorously (Plates 3 and 4) without any symptom of bud abnormality (Plate 3, right plant) in culture solution No. 3, Type I, when boric acid was added to the culture solution. The plants grown in culture solution No. 3, Type I, but without boric acid (first two plants from the left, Plate 3) showed the same bud abnormality as had been described elsewhere in this paper upon reaching the age of 90 days. And at the more advanced stage of abnormal development, when they were 103 days old, the buds of these boronless plants died. Similarly, the plants grown by the sand culture method and fed with the same culture solution (culture solution No. 3 of Type I) from January 2 to March 2 of 1936 also showed symptoms of abnormal growth (pointed by arrows) of the young leaves making up the bud (Table 4 and Plate 4, back plants). On March 2, boron was then introduced into each of the culture medium. Normal leaves were then again developed by the plants (leaves above arrow) as shown in Plate 4 (back plants) after a period of 4 weeks. The other two plants (front), which were continuously fed with culture solution No. 3, Type I, for the same length of time, had dead terminal buds. This behavior of the tobacco plants grown under the conditions herein described (both water and sand culture method) shows that boron, especially for tobacco, is essential and therefore must be present in the nutrient medium. This result further substantiates the recent findings on the nutrition of higher plants that boron is to be included as one of the essential elements for normal growth of these plants. It is one of the rare elements and like the rest of the rare elements, it was heretofore considered not essential to the growth of higher plants.

Preference of NO_3-nitrogen over NH_4-nitrogen.—The tobacco plant showed decided preference to nitrate-nitrogen over ammonia-nitrogen. The results of *Trial 3* (Tables 5 and 6) show that when the source of nitrogen was from $(NH_4)_2SO_4$, the rate of growth of the tobacco plant (Plate 5) was greatly retarded, if not inhibited; whereas when $Ca(NO_3)_2$ was supplied, the plant did not only show vigorous growth but also reached full maturity (Plate 5). It is apparent from this fact that under

field conditions ammonia-nitrogen has to be converted into nitrate-nitrogen by nitrifying bacteria in order to become readily available to the tobacco plant. This contention is supported by the absence of nitrate obtained from the drainage of culture bottles Nos. 1, 2, and 3, Table 5, which were supplied with ammonium salts. Similarly, nitrate-nitrogen was absent in control bottles Nos. 7, 8, and 9, Table 5, which were treated identically as culture bottles Nos. 1, 2, and 3 except that no plants were grown in them. It is obvious, therefore, that the absence of nitrate-nitrogen in the drainage of cultures Nos. 1, 2, and 3 was not due to the immediate absorption of nitrate-nitrogen by the roots as fast as it was converted from ammonia-nitrogen by the nitrifying bacteria but was due to the absence of the necessary nitrifying bacteria in the culture medium to effect the necessary transformation of the ammonium salts into the nitrate form. Tobacco is, therefore, unlike other crop plants like the pineapple which according to Stewart(6) and others, is capable to assimilate all its nitrogen in the form of ammonium salts, although the best growth was made by those growing in solutions in which the nitrogen was present in the form of nitrates. Also the results of numerous investigators on the nitrogen nutrition of many plants indicate that some plants grow equally well with both nitrates and ammonium salts and that others, although assimilating nitrogen in the absence of nitrates, seem to prefer nitrates. It is now clear that the tobacco plant belongs to the latter group. This nutrient requirement of the tobacco plant is, therefore, extremely important to consider in the application of commercial fertilizers in tobacco fields. Ammonium salts may be also applied, but the acidity of the soil must be taken into consideration, because the nitrogen-fixing bacteria are very intolerant to acid. Under such condition it is advisable to apply the nitrate salts in the tobacco field instead of the ammonium salts.

The effect of adding $Ca(H_2PO_4)_2$ to a complete nutrient medium.—The addition of a small quantity of $Ca(H_2PO_4)_2$ to a nutrient medium containing KH_2PO_4, $Ca(NO_3)_2$, $MgSO_4$, $FePO_4$ and H_2BO_3 improved the nutritive value of the mixture as shown by better growth developments to tobacco plants grown with it than when without $Ca(H_2PO_4)_2$ (Plate 6 and Table 7). The total concentration (gram-molecule per liter) and molecular proportion of the salts employed in the two culture media were the same. The only noticeable differences of the two culture media used were due to more Ca and PO_4 ions in the nutrient medium containing $Ca(H_2PO_4)_2$. These two ions were, however, also

found in the other culture medium only that they were present in fewer number. This difference brought about in the latter a reduction in growth development of the tobacco plant. The plant grown in culture medium with $Ca(H_2PO_4)_2$ had a total dry weight (roots, stem, and leaves) of 11.03 grams as against 9.54 grams of the other. The leaf products of green leaves of the former averaged 1,729.5 sq. cm; that latter, 1,468.1 sq. cm. There were, however, no noticeable differences observed as regards the quality of the leaves harvested from the two culture media.

Influence of concentration on the growth of tobacco.—The nutrient medium, which was found to grow tobacco to full maturity under controlled condition (sand culture), had about .0022 gram-molecule per liter (all salts taken together), the salts being present in about the following molecular proportions:

KH_2PO_4: $Ca(NO_3)_2$: $Ca(H_2PO_4)_2$: $MgSO_4$ = 2:6:1:2.$FePO_4$ and H_3BO_3 were added to the culture solution in the amount of 2.5 cc per liter for the former and 0.5 cc p.p.m. for the latter (Table 5 and Table 6). Results of *Trial 5* show that when the molecular proportion of the salts employed was kept constant but the total concentration was made variable, the growth development of the plants grown therein varied a great deal. Repeated trials on the determination of the optimum concentration for tobacco show that .0132 molar was better than 0.0022, Table 10.

Height of plants.—The height of the plants was affected by the total concentration of the nutrient medium. A total concentration of the nutrient medium as low as .00055 molar or as high as 0.022 were both not favorable nor conducive to rapid growth of the tobacco plant. The best strength of the solution mixture tried was found to be 0.0132 molar. The plants grown therein had reached an average height of 96.2 cm at the age of 103 days. Plants grown in nutrient media with concentrations lower or higher than .0132 molar were shorter. When the plants were arranged in the order of height beginning from the highest to the lowest, the order of the total concentration of the solution employed was .0132, .0088, .0022, .022, and .00055 molar, respectively. When a value of 100 is given to the highest plant (in the .0132 molar), the relative value of the height of the other plants arranged in the same order from the highest to the lowest would be 100, 96, 90, 68, and 33.

The plants which grew the highest also produced the biggest leaves. When the dry weight of the whole plants was considered (roots, stem, and leaves), the plant grown in the .0132 molar was also the heaviest. It is apparent, therefore, that .0132 molar was the optimum concentration for tobacco. This concentration, .0132 molar, is very much higher than the optimum concentration of the nutrient medium tried for rice. According to Espino(1), the most promising solution for this plant has about 0.002 gram-molecule per liter (of all salts). This strength is approximately six and six-tenths weaker than that one best for tobacco. Judging from the concentration requirement of the two kinds of plants, it can be interpreted that tobacco is a heavier consumer of food elements present in the soil than rice. This is obvious when one observes the relative sizes of fully matured rice and tobacco plants and especially so when the relative sizes of the seed materials are taken into consideration.

SUMMARY AND CONCLUSION

The sand and solution culture methods were employed in the study of the salt requirement of tobacco plant, with special reference to the variety *Ilagan Sumatra*. Sixteen-day-old seedlings (from sowing) germinated in quartz sand were employed. The results of the different trials point to the following:

1. The most promising nutrient medium for tobacco has about 0.0132 gram-molecule per liter (of all salts), the salts being present in about the following molecular proportions: KH_2PO_4: $Ca(NO_3)_2$: $Ca(H_2PO_4)_2$: $MgSO_4 = 2:6:1:2$. As usual, trace of iron in the form of ferric phosphate or ferrous sulphate is added to the culture medium.

2. In addition to the 10 essential elements, namely, carbon, hydrogen, oxygen, phosphorus, potassium, sulphur, nitrogen, calcium, iron, and magnesium needed for normal growth of higher plants, a little amount of boron is absolutely necessary to be present in the nutrient medium in order for the tobacco plant to develop to full maturity. Its absence in the nutrient medium causes the death of the terminal bud of the tobacco plant.

3. The addition of a small quantity of $Ca(H_2PO_4)_2$ to a nutrient medium containing KH_2PO_4, $Ca(NO_3)_2$, $MgSO_4$, $FePO_4$ and H_3BO_3 improves the nutritive value of the mixture.

4. The tobacco plant develops vigorously in a complete nutrient medium containing nitrate-nitrogen. In using ammonium sulphate as source of nitrogen in the absence of nitrifying bacteria, the growth of the plants is greatly retarded, if not inhibited.

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ILLUSTRATIONS

TEXT FIGURE

FIG. 1. Longitudinal section of a 1-liter bottle employed in sand culture work.

PLATE 1

a. Showing the plants as they appeared on March 1, 1935. The salts used in culture media are shown in Table 1.

b. Showing the same plants (1-a) as they appeared on April 11, 1935. The salts used in culture media are shown in Table 1. Plants were harvested on April 11. Numerical data are in Table 2.

PLATE 2

Showing the plants as they appeared on April 11, 1936. The salts used in culture media are shown in Table 1. Note the deformed young leaves (indicated by arrows) of the tall plants.

PLATE 3

Showing the plants as they appeared when they were 103 days old (from sowing). Plant on the right was grown in complete nutrient solution with H_3BO_3. The other two plants were also grown in complete nutrient solution but without H_3BO_3. Note the terminal buds. Description of plants are in Table 3.

PLATE 4

Showing plants (sand culture) as they appeared when they were 103 days old (from sowing). At the start, the four plant were all fed with culture solution No. 3 of Type I. At the age of 75 days, abnormal growth of leaf was noted as shown by arrows. H_3BO_3 was then introduced into the culture media. The other two plants (front) were fed continuously with culture solution No. 3 of Type 1. Note the condition of the terminal buds.

PLATE 5

Showing plants as they appeared when they were 115 days old. The salts used in culture media are shown in Table 5. Plant on the left was supplied with ammonia nitrogen (—$(NH_4)_2SO_4$) and the other, right with nitrate nitrogen ($Ca(NO_3)_2$). Description of plants is presented in Table 6.

PLATE 6

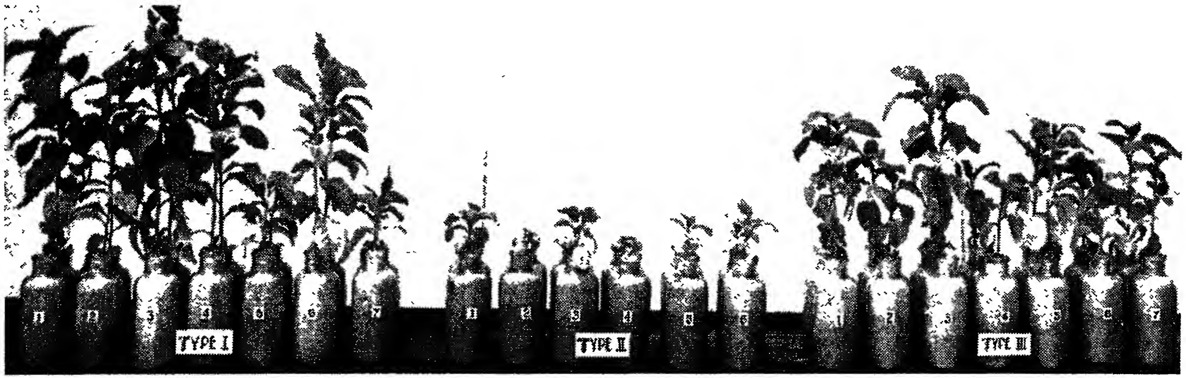
Showing plants as they appeared when they were 103 days old. The salts used in culture media are shown in Table 7. Numerical data are presented in Table 8. Two plants on the right were fed with $Ca(H_2PO_4)_2$ and in the other two plants (left) $Ca(H_2PO_4)_2$ was absent in the culture media.

PLATE 7

a. Showing plants (first trial) as they appeared when they were 95 days old. The salts used in culture media are shown in Table 9 and culture bottles were arranged from lowest (left) to highest (right) concentration.

b. Showing plants (second trial) as they appeared when they were 103 days old. The salts used in culture media are shown in Table 9 and culture bottles were arranged in the same order as of Plate 7-a. Harvest data are presented in Table 10.

a



b

PLATE 1.

PLATE 2.

PLATE 3.

PLATE 4.

PLATE 5.

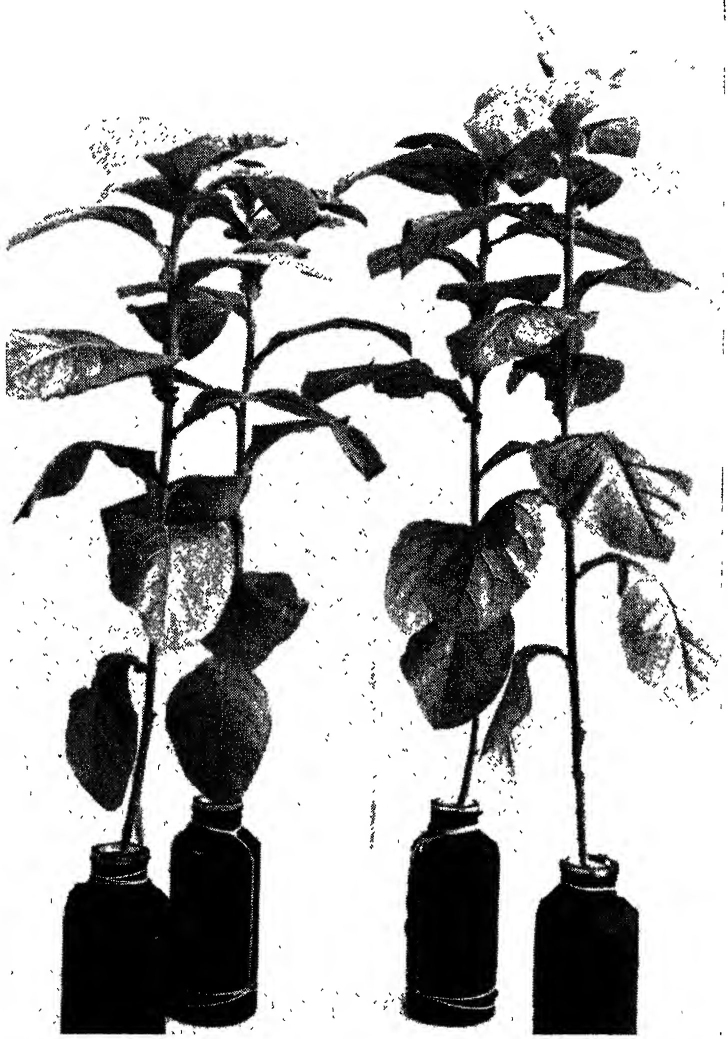


PLATE 6.

a

b

PLATE 7.

SOME OBSERVATIONS ON THE LIFE HISTORY, HABITS, AND CONTROL OF THE RICE CASEWORM, NYMPHULA DEPUNCTALIS GUEN.

By PEDRO SISON

Of the Plant Pest and Disease Control Division

FOUR PLATES AND ONE TEXT FIGURE

The rice caseworm, *Nymphula depunctalis* Guen., is one of the most important rice pests in the Philippines, causing at times serious damage. During the years 1927 and 1929, infestations by this pest were reported alarming in the Ilocos provinces, Pampanga, Tarlac, Bulacan, and Rizal by fieldmen of the old Bureau of Agriculture (now Bureau of Plant Industry) stationed in these provinces. Aniceto G. Toquero, assistant agronomist, reported in 1934 that it was serious in the provinces of Bulacan and Nueva Ecija. In the municipality of San Jose, Nueva Ecija, alone, Toquero observed an area of about fifty hectares so seriously damaged by the pest that the owners decided to replant the entire area in order to obtain a paying crop. Similar cases of this nature have been observed by the writer in other rice-growing regions. In fact the injuries caused by this pest are the subjects of complaints received by the Bureau of Plant Industry from rice growers every year.

This study was, therefore, conducted with the object of obtaining data or information on the life history, habits, and control of this important pest of lowland rice so that growers who are often troubled by this insect may be helped. The observations in this paper may also serve as a basis for further investigation.

CLASSIFICATION AND VERNACULAR NAMES

The insect belongs to the Order Lepidoptera (Heterocera), Family Pyralidæ. The adults reared during this study and those collected from the field agree with the descriptions by Maxwell-Lefroy(6) and Dammerman(1) who identified the insect as *Nymphula depunctalis* Guen. (*stagnalis* Zell). Furthermore,

the adult specimens reared in this work were found identical with those in the collection of the Philippine Bureau of Science, Manila. The Bureau of Science specimens were collected from lighted spots near "zacate" fields within the City of Manila on October 11, 1906, and were identified by Charles S. Banks, former entomologist of the said Bureau, as *Nymphula depunctalis* Guen, basing his identification on Hampson's (1896) description of the species in the later Fauna of British India (Vol. IV., p. 185).

Hampson (5) and Moore (9) listed the following as synonyms of the species:

Nymphula staynalis Zell. (1852)
Zebronia decussalis Wlk. (1854)
Hydrocampa depunctalis Guen. (1854)

The pest is commonly known as the rice caseworm, because the caterpillars have the habit of enclosing themselves in pieces of rice or grass leaves in the form of cases, or coverings. The leaf cases undoubtedly serve as a protection for the larvæ from natural enemies and also as a float to facilitate movement from one plant to another.

In the Tagalog provinces, rice farmers call the pest "aksip na puté" (white malady), a term applied to the effect of the insect's injury as the infested fields, as a whole, appear white from a distance and are clearly distinguishable from the non-infested portions of the field. In the Ilocos provinces, it is named "cutalo," while in the Province of Pampanga, the pest is known as "dalukat aputi," etc.

GEOGRAPHICAL DISTRIBUTION

In the Philippines, Woodworth (13) and Uichanco (12) listed this insect as one of the pyralid pests of rice. According to Dammerman (1), Miller and Padgen (8), and Corbett (2) this insect is often serious on rice in the Malay Archipelago. In India, Gupta (4) reports its presence on rice in Assam Province and Ramakrishna (11) in South India. Maxwell-Lefroy (7) also states that *Nymphula depunctalis* is widely distributed and is common in India. Ghosh (3) says it is of common occurrence in lower Burma. Wardle (14) referred to this insect as one of the chief pests of rice in Southeastern Asia, which comprises

China, Japan, Formosa, the Philippines, Indo-China, the Malay Peninsula, East Indies, India, and Ceylon. Leefmans (8) also mentioned it on rice in the Dutch East Indies.

This pest is, therefore, widely distributed, being known to occur wherever lowland rice is grown.

NATURE AND EXTENT OF DAMAGE

The larvæ, soon after emerging from the eggs, begin to feed on the lower surfaces of the tender leaves of rice or grasses, leaving the upper epidermis which is papery and which gives the infested plants their characteristic white appearance. Most of the tips of the leaves are cut, because these severed portions are used by the larvæ for their cases, or coverings (Plate 3). When young seedlings are attacked by four or more larvæ per stool, as observed under field conditions, almost all the lower surfaces of the leaves are usually eaten up within a few days and the destroyed portions of the leaves soon dry out. This renders the plants leafless and become greatly stunted. When the rice plants are injured to this extent, it may take them about a month to recover. However, when adverse weather conditions follow and the field is overgrown by weeds, the whole planting may become useless and replanting may be necessary.

Not only are the transplanted seedlings attacked by this pest but also those still in the seed beds, as was observed in Arayat, Pampanga, in 1936. After a serious attack, the seedlings in the seed beds appear as though they were affected by drought, because the infested leaves become dry even if the stems are still fresh.

The larvæ also attack older seedlings, but the rice plants can better resist the injury and recover more readily as the growth is only little retarded. When the pest, however, still appears in paddies where the rice plants approach maturity, the larvæ no longer bother them, because the leaves are already tough and instead, they feed on the leaves of grasses growing among the rice plants.

The infestations occur in patches, ranging from a few paddies of limited area to many solid hectares. Solid infestations in one locality may even reach as much as fifty hectares or more in extreme cases, as was observed by Mr. Toquero in the municipality of San Jose, Nueva Ecija, during the year 1934. The plants that recovered from the attack of the pest are stunted,

and therefore head at a much later time. The panicles produced are smaller than those of the plants not or only slightly affected.

HOST PLANTS

Rice is preferred by the larvæ of this insect, but they also subsist on the leaves of grasses. The insect seems to show no decided preference to any variety of lowland rice, as has been observed in several provinces. In Pampanga, for example, it was observed to feed on the varieties macan, elon-elon, and ramai. In Rizal province, it attacks the macan and malagkit, or glutinous varieties. In the Bicol provinces, it occurs on the varieties baranay and senador, or apostol, etc.

Among the grasses, found in the province of Rizal, on which the pest feeds, as identified by E. Karganilla of the Bureau of Science, are the following:

1. *Panicum carinatum* Presl.
2. *Panicum colonum* Linn.
3. *Eragrostis interrupta* (R. Br.) Beauv.
4. *Paspalum scrobiculatum* Linn. var. *vispicatum* Hack.
5. *Panicum stagninum* Retz.
6. *Panicum distachyum* Linn. and
7. *Panicum repens* Linn.

These grasses are mostly found growing on and along the paddy dikes. The pest was observed to feed mostly on *Panicum carinatum*, which is the most common grass found among the rice plants.

LIFE HISTORY

Materials and methods of study.—The study of the life history of the pest was conducted in the Entomology Laboratory of the Bureau of Plant Industry, Manila. For this purpose, three different containers were used; namely, ordinary test tubes, petri dishes (5 in. x 1 in.), and battery jars (8 in. high and 6 in. diameter).

Larvæ in their cases, collected in Rizal province, were reared in battery jars by feeding them with green leaves of the genus *Panicum*. To keep the leaves as fresh as possible, little water was placed at the bottom of each battery jar. As soon as the adults emerged, couples were picked out and placed in separate petri dishes. Fresh grass and cotton soaked in a sugar solution

were placed in each dish. The cut ends of the grass shoots were wrapped with wet cotton to prevent rapid drying. The grass served as a medium for the insects to deposit their eggs and the sugar solution as food for the adults. In this way, egg laying and the fecundity of the species were observed.

The newly hatched larvæ were separated, and each larvæ was placed in a petri dish. Water and rice seedlings were placed in a petri dish, and were changed daily so as to give the developing larvæ fresh water and leaf throughout their lifetime. The water is about 2 millimeters deep from the bottom of the petri dish. Moltings were recorded in this culture, and as soon as the larvæ pupated, the water in the petri dish was removed and wet cotton was placed instead. The purpose of the latter was to keep the container moist for some time to prevent the pupæ and the rice seedlings from rapid drying. Such a condition is necessary to allow the pupæ to develop into adult. The excess water in the petri dish was removed to prevent the emerging adults from drowning.

Individual rearings were also made in test tubes. By this method the leaves of the rice seedlings were inserted into the test tube and the mouth was loosely closed with cotton to keep the rice stem from moving and at the same time prevent the larvæ from escaping. The root stock which was outside the test tube was wrapped with wet cotton to keep the seedling fresh for some time. A little water was placed inside the test tube where the larva could float. The rice seedling and the water were changed whenever necessary.

There were four sets of individual cultures in petri dishes, two during the month of May, 1935, consisting of eleven individuals, one during June and another one during October of the same year, consisting of six and twenty-four individuals, respectively. Two sets were studied in test tubes. One was during the month of November, 1934, consisting of sixteen individuals and the other during April, 1935, consisting of thirty-one individuals. Mass cultures were in battery jars. Two cultures were under observation in October, 1935.

(*a*) *Period from emergence to egg laying.*—Observations were made on thirty-eight females beginning from the date of emergence. Thirty of these females laid eggs after one to four days with an average of 2.54 days. The records made on these moths are shown in the following table:

TABLE 1.—*Period from emergence of the adults to egg laying.*

Number	Date of emergence	Date first eggs laid	Number of days
	1935	1935	
1	January 2	January 4	2
2	January 3	January 5	2
3	January 4	do	1
	do	January 8	4
4	January 7	January 9	2
	do	January 10	3
6	January 18	January 21	3
7	January 21	January 24	3
8	January 23	January 25	2
9	March 4	March 6	2
	do	March 7	3
10	March 6	March 9	3
14	March 16	March 18	2
15	March 18	March 20	2
19	March 25	March 29	4
21	April 2	April 5	3
22	April 5	April 7	2
23	May 2	May 4	2
24	do	May 5	3
25	May 15	May 17	2
26	May 31	June 2	2
27	June 3	June 3	3
28	do	June 1	2
29	do	June 6	3
30	October 2	October 6	4
31	October 28	October 31	3
32	do	do	3
33	October 29	do	2
34	October 28	do	3
35	October 30	November 1	2
36	do	do	2
37	do	November 2	3
38	October 31	November 2	2
Average			2.54

Minimum	1 day
Maximum	4 days

(*b*) *Incubation period.*—Thirty groups of eggs were laid during the study and only seventeen of them proved to be fertile. They hatched in two to six days with an average of 3.41 days, as shown in Table 2.

(*c*) *Duration of the larval stage.*—Records and observations were made on twenty-four individuals reared successfully in test tubes. The larvæ in these test tubes pupated after 25 to 42 days with an average of 30.62 days, as shown in Table 3. In the case of individual rearings, with the use of petri dishes as containers, the length of the larval stage was very much shorter

TABLE 2.—*Incubation period.*

Culture number	Date eggs laid	Date eggs hatched	Interval
	1934	1934	Days
1	October 17	October 20	3
	1935	1935	
10	March 9	March 12	3
14	March 18	March 22	4
15	March 20	March 23	3
15	do	March 24	4
19	March 29	April 4	6
20	April 3	April 5	2
20	do	April 6	3
21	April 5	April 9	4
22	April 7	April 10	3
22	do	April 11	4
23	May 4	May 7	3
24	May 5	May 9	4
26	June 2	June 4	2
27	June 3	June 6	3
27	do	June 7	4
30	October 6	October 9	3
Average			3.41

Minimum .... 2 days
Maximum .... 6 days

as records on 34 individuals show. It lasts from 14 to 20 days only with an average of 15.85 days (Table 4). In the case of the mass cultures in battery jars, the length of the larval stage varied from 15 to 19 days with an average of 16.67 days, as shown in Table 9.

The length of larval stage of those reared in petri dishes and battery jars was about the same, while those reared in test tubes, the length was almost double. This discrepancy in development may possibly be due to the fact that in the test tubes the pest is so confined that its development is greatly retarded.

(*d*) *Duration of larval moltings.*—The larva molts four times before pupation. The duration of larval instars as observed from those individuals reared in test tubes are as follows; first instar larva lasts from four to fifteen days with an average of 9.25 days; the second from four to nine days with an average of 6.75 days; the third from three to nine days with an average of 6.25 days; the fourth from three to ten days with an average of 6.5 days; and the fifth from four to eleven days with an average of 6.12 days. The durations of the different instars in this case are almost twice as those reared in petri dishes (Table 5).

TABLE 3.—*Duration of the larval stage with test tubes as containers.*

Number	Date eggs hatched	Date larvæ pupated	Interval
	1934	1934	Days
2	October 20	November 27	38
4	do	November 14	25
5	do	November 19	30
6	do	December 1	42
7	do	November 14	25
9	do	December 1	42
10	do	November 30	41
13	do	November 20	31
14	do	November 22	33
	1935	1935	
A-1	April 10	May 7	27
3	do	do	27
5	do	May 10	30
6	do	May 12	32
9	do	May 9	29
B-1	April 11	May 8	27
4	do	May 6	25
6	do	do	25
8	do	do	25
10	do	May 9	28
13	do	May 12	31
14	do	May 9	28
16	do	May 7	26
18	do	May 9	28
21	do	May 20	29
Average			30.62

Minimum .... 25 days
Maximum .... 42 days

Results obtained from the individual cultures, using petri dishes as containers, show that the first instar larva lasts from two to three days with an average of 2.68 days; the second instar, from two to three days with an average of 2.39 days; the third, from two to three days with an average of 2.43 days; the fourth, from three to five days with an average of 3.3 days; and the fifth from four to six days with an average of 4.78 days (Table 6).

(*e*) *Duration of the pupal stage.*—The length of the pupal, or resting, stage as observed under the three different methods of rearing described varies slightly. In test tubes the duration varied from 5 to 7 days with an average of 5.78 days (Table 7); in petri dishes, from four to seven days with an average of 5.09 days (Table 8); and in battery jars, from five to seven days with an average of six days (Table 9).

TABLE 4.—*Duration of the larval stage in petri dishes.*

Number	Date eggs hatched	Date larvæ pupated	Interval
	1935	*1935*	*Days*
C -1	May 7	May 23	16
2	do.	May 22	15
3	do.	May 24	17
4	do.	May 23	16
5	do.	May 25	18
6	do.	May 26	19
7	do.	May 27	20
D -1	May 9	May 25	16
2	do.	do.	16
5	do.	do.	16
6	do.	May 24	15
E -2	June 6	June 20	14
3	do.	June 22	16
5	June 7	June 23	16
6	do.	June 21	14
F -1	October 9	October 25	16
2	do.	October 24	15
3	do.	October 25	16
4	do.	do.	16
5	do.	October 24	15
7	do.	do.	15
8	do.	October 25	16
9	do.	October 26	17
10	do.	October 24	15
11	do.	October 26	17
12	do.	October 25	16
13	do.	October 24	15
14	do.	do.	15
15	do.	do.	15
16	do.	October 26	17
17	do.	October 24	15
18	do.	October 26	17
19	do.	October 24	15
20	do.	October 27	18
Average			15.85

Maximum .... 20 days
Minimum .... 14 days

(*f*) *Summary of the life cycle from egg to egg.*—The length of the life cycle of the insects that were reared in petri dishes from the time the eggs are laid up to that when the adults begun to lay their eggs is from 21 to 37 days with an average of 26.89 days (Table 10).

(*g*) *Longevity of the adult stage under captivity.*—Under laboratory conditions, the newly emerged adults were placed in petri dishes, two in each, and fed with sugar solution. They began to die two days after confinement, and the longest period

TABLE 5.—*Duration of larval moltings with test tubes as containers.*

Number	Date hatched	Date of first molt	Interval	Date of second molt	Interval	Date of third molt	Interval	Date of fourth molt	Interval	Date pupated	Interval
	1934	*1934*	*Days*	*1934*	*Days*	*1934*	*Days*	*1934*	*Days*	*1934*	*Days*
2	October 20	October 27	7	November 4	8	November 13	9	November 20	7	November 27	7
5	do	October 24	4	October 29	5	November 7	9	November 12	5	November 19	7
6	do	October 30	10	November 7	8	November 12	5	November 20	8	December 1	11
7	do	October 29	9	November 4	6	November 7	8	November 10	3	November 14	4
9	do	October 30	10	November 8	9	November 17	9	November 27	10	December 1	4
10	do	November 4	15	November 10	6	do	7	November 24	7	November 30	6
13	do	October 29	9	November 2	4	November 7	5	November 11	4	November 20	9
14	do	October 30	10	November 7	8	November 10	3	November 18	8	November 22	4
	Average		9.25		6.75		6.25		6.5		6.12

TABLE 6.—*Duration of larval moltings with petri dishes as containers. (Individuals that failed to develop were omitted)*

Number	Date hatched	Date of first molt	Interval	Date of second molt	Interval	Date of third molt	Interval	Date of fourth molt	Interval	Date of pupation	Interval
	1935	*1935*	*Days*	*1935*	*Days*	*1935*	*Days*	*1935*	*Days*	*1935*	*Days*
E-2	June 6	June 8	2	June 10	2	June 12	2	June 15	3	June 20	5
3	do	do	2	June 11	3	June 13	2	June 16	3	June 22	6
5	June 7	June 9	2	June 12	3	June 15	3	June 18	3	June 23	5
6	do	do	2	June 11	2	June 13	2	June 16	3	June 21	5
F-1	October 9	October 12	3	October 14	2	October 17	3	October 21	4	October 25	4
2	do	do	3	do	2	October 16	2	October 20	4	October 24	4
3	do	do	3	October 15	3	October 18	3	October 21	3	October 25	4
4	do	do	3	do	3	October 17	2	October 20	3	do	5
5	do	do	3	October 14	2	October 16	2	October 19	3	October 24	5
7	do	do	3	do	2	do	2	October 21	5	October 25	4
8	do	do	3	do	2	October 17	3	October 20	3	October 26	6
9	do	do	3	do	2	do	3	do	3	October 24	4
10	do	October 11	2	do	3	do	2	October 21	4	October 26	5
11	do	October 12	3	October 15	3	do	3	do	4	October 25	4
12	do	do	3	October 14	2	October 16	2	October 19	3	October 24	5
13	do	do	3	do	2	do	2	do	3	do	5
14	do	do	3	do	2	October 17	3	October 20	3	do	4
15	do	do	3	do	2	October 18	2	October 21	3	October 26	5
16	do	do	3	October 15	3	October 16	2	October 19	3	October 24	5
17	do	do	3	October 14	2	October 18	3	Ocotber 21	3	October 26	5
18	do	do	3	October 15	3	October 16	3	October 19	3	October 24	5
19	do	October 11	2	October 13	2	do	2	October 21	5	October 25	4
20	do	October 12	3	October 15	3	October 18	3	October 22	4	October 27	5
	Average		2.68		2.39		2.43		3.3		4.78

TABLE 7.—*Duration of the pupal stage with test tubes as containers.*

Number	Date larva pupated	Date adult emerged	Interval
	1934	*1934*	*Days*
5	November 19	November 26	7
6	December 1	December 6	5
7	November 14	November 20	6
9	December 1	December 7	6
10	November 30	December 5	5
14	November 22	November 28	6
	1935	*1935*	
A-1	May 7	May 14	7
3	do	May 12	5
5	May 10	May 15	5
6	May 12	May 18	6
9	May 9	May 15	6
B-1	May 8	May 13	5
4	May 6	May 12	6
6	do	do	6
8	do	May 11	5
10	May 9	May 15	6
13	May 12	May 17	5
14	May 9	May 16	7
18	do	May 15	6
Average			5.78

Maximum .... 7 days
Minimum .... 5 days

that an adult was observed to live under such condition is eight days. It was noted, however, that before the females died, they had laid on the average more than one-half of their eggs. The following table shows the records obtained from twenty-five individuals.

HABITS

(*a*) *Adult.*—The adults are nocturnal in habit and are attracted to house lights at night. During the day, they hide under the leaves of rice and grasses, oftentimes in association with the adults of the rice leaf-folder, (*Cnaphalocrosis medinalis*) and fly readily when disturbed. When the adult is at rest the wings are expanded and are pressed against the object where it rests, as a leaf, for example. In no instance was copulation observed during the day either in the field or in the laboratory. So it is presumed that mating takes place only during the night.

Egg laying also takes place at night, the eggs being deposited on the lower surfaces of the leaves as well as on the stems of rice and grasses just a little above the surface of the water. In the field, eggs have also been observed on floating empty leaf cases of the worms. They are placed in rows of one or two,

TABLE 8.—*Duration of the pupal stage with petri dishes as containers.*

Number	Date larva pupated	Date adult emerged	Interval
	1935	*1935*	*Days*
C-1	May 23	May 30	7
3	May 24	do.	6
4	May 23	do.	7
5	May 25	May 31	6
6	May 26	do.	5
7	May 27	June 1	5
D-1	May 25	May 30	5
2	do.	May 31	6
5	do.	do.	6
6	May 24	do.	7
E-2	June 20	June 25	5
3	June 22	June 27	5
5	June 23	June 29	6
6	June 21	June 26	5
F-1	October 25	October 30	5
2	October 24	October 29	5
3	October 25	October 31	6
4	do.	October 29	4
5	October 24	October 28	4
7	do.	October 29	5
8	October 25	October 30	5
9	October 26	do.	4
10	October 24	October 29	5
11	October 26	October 30	4
12	October 25	do.	5
13	October 24	October 28	4
14	do.	October 29	5
15	do.	do.	5
16	October 26	October 30	4
17	October 24	October 28	4
18	October 26	October 30	4
19	October 24	October 29	5
20	October 27	October 31	4
Average			5.09

Maximum .... 7 days
Minimum .... 4 days

TABLE 9.—*Life cycle in mass culture with battery jars as containers.*

Date eggs laid	Date eggs hatched	Interval	Date larva pupated	Interval	Date adults emerged	Interval	Total number of days	Number of individuals
1935	*1935*		*1935*		*1935*			
			Culture No. 1					
Oct. 4	Oct. 7	3	Oct. 23	16	Oct. 30	7	26	
			Oct. 24	17	Oct. 31	7	27	8
			Oct. 26	19	Oct. 31	6	28	
			Culture No. 2					
Oct. 9	Oct. 11	3	Oct. 26	15	Oct. 31	6	24	
			Oct. 27	16	Nov. 2	6	24	11
			Oct. 28	17	Nov. 2	5	25	
Average		3		16.67		6	25.5	

TABLE 10.—*Summary of life cycle from egg to egg.*

Stage of the pest	Duration in days	Average number of days	Remarks
Egg stage	2 to 6	2.41	Reared in petri dishes.
Larval stage	14 to 20	15.85	Do.
Pupal stage	4 to 7	5.09	Do.
Emergence of adult to egg laying	1 to 4		Do.
Total	21 to 37	26.89	

TABLE 11.—*Longevity of the adult stage under captivity.*

Individual number	Date emerged	Date died	Interval	Sex
	1935	*1935*	*Days*	
1	January 2	January 5	3	Female.
2	January 3	do	2	Male.
3	do	January 7	4	Female.
4	January 4	January 10	6	Male.
5	do	do	6	Female.
6	January 7	January 12	5	Male.
7	do	do	5	Female.
8	January 10	January 14	4	Male.
9	do	do	4	Female.
10	January 26	January 29	3	Female.
11	do	do	3	Male.
12	do	January 30	4	Female.
13	October 28	October 4	7	Do.
14	do	October 5	8	Do.
15	do	October 2	5	Do.
16	do	do	5	Do.
17	October 29	October 4	6	Male.
18	do	do	6	Do.
19	do	do	6	Female.
20	do	October 2	4	Do.
21	October 30	October 4	5	Male.
22	do	do	5	Do.
23	do	do	5	Female.
24	do	October 3	4	Do.
25	do	October 5	6	Do.
Average			4.8	

Maximum .... 8 days
Minimum .... 2 days

numbering to as many as twenty-one. In the laboratory they were found laid without any definite arrangement on the sides of the containers where they were kept in confinement. In most cases the females laid their eggs all at once during their lifetime, but a few individuals were observed to have laid their eggs at two different times before they died (see Table 12).

(*b*) *Larva.*—The larvæ commence to feed on the same day they hatch, and after two days they begin to enclose themselves

in cases out of the young leaves of rice or grasses, as the case may be. On rice, a caterpillar crawls up to about the tip of young rice leaf and cuts the upper end. It then turns back, facing downward, and begins to fold both edges of the leaf with its silklike threads. As soon as the leaf is completely folded, it cuts the bottom end of the folded portion until the case, or covering, thus formed is severed from the leaf. It holds the leaf with its legs having its head and thorax out of the case and hangs in a slanting position. When casing is done on grass with short leaves, the caterpillar selects a leaf suitable to its length and folds the leaf without further cutting the tip. After this is done, the bottom end, right at the base of the leaf, is then severed. There are several ways by which the caterpillar incloses itself in a leaf but the two described above are the most common.

The larva molts four times, from hatching to pupation, and it also changes its case the same number of times, each change taking place before each molt. When full-grown, the larvæ with their cases, or coverings, lodge on the stems of the rice plants or on any other objects just a little above the surface of the water. The cases are first attached to the stem of rice or any other objects parallel to the latter with their silky threads through a little opening at about the middle of the cases. They then pupate inside (Plate 3, fig. 1). The adults emerge from these cases during night coming out through an opening at the upper end.

c. Number of eggs laid by each female.—The females under observation in the laboratory laid from 3 to 103 eggs during their lifetime, with an average of 52.2. However, after the females died, they were dissected, and the developed eggs in their ovaries were counted. From 0 to 93 eggs were found, with an average of 28.9. Taking the total of the laid and unlaid eggs, each female may have a laying capacity, under field conditions, of from 47 to 103 eggs with an average of 81.1. Table 12 shows the records obtained from the ten females understudy.

(*d*) *Sexual ratio.*—The number of adult males and females was counted as they emerge from larvæ that were reared in the mass cultures. Those that emerged from the individual cultures were likewise counted. It was observed that out of the 159 adults counted, 84 were males and 75 were females, or there was a ratio of 50 to 45 in favor of the males. In nature the sexual ratio is about equal (Table 13).

TABLE 12.—*Fecundity.*

Female number	Date of first laying	Number of eggs	Date of second laying	Number of eggs	Total laid	Date died	Number of developed eggs counted after dissecting	Total number of eggs laid and unlaid
	1935		*1935*			*1935*		
1	Jan. 4	3			3	Jan. 6	69	72
2	Jan. 5	38			38	do	36	74
3	do	22	Jan. 8	7	29	Jan. 9	33	62
4	Jan. 9	25	Jan. 10	13	38	Jan. 10	9	47
23	May 4	97			97	May 5	0	97
24	May 5	40			40	May 6	23	63
27	June 3	67			67	June 10	26	93
28	June 1	9			9	June 2	93	102
36	Nov. 1	68	Nov. 2	30	98	Nov. 4	0	98
37	Nov. 2	77	Nov. 3	26	103	do	0	103
	Average	44.6		7.6	52.2		28.9	81.1

Minimum number of eggs laid 3
Maximum number of eggs laid 103

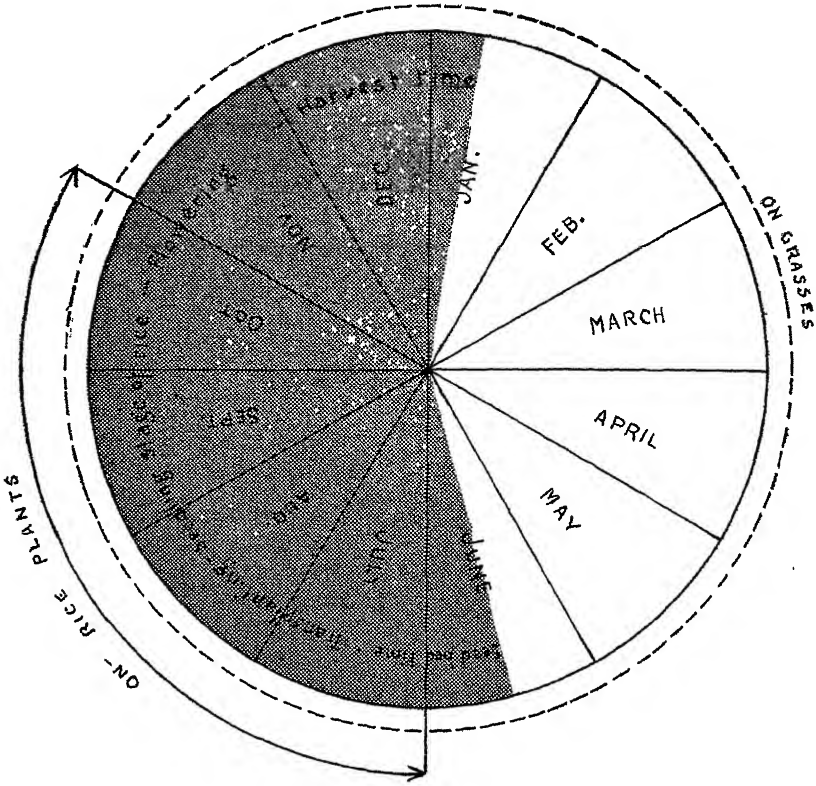
(*e*) *Prevalence.*—From the month of July to November, the caterpillars are abundant and feed on the leaves of rice plants and grasses growing in the paddies. During these months the leaves of rice are still soft and tender and are, therefore, very susceptible to their attack. From the month of November to July of the succeeding year, they breed on grasses growing in the rice fields and in other places where there is always water, as springs, pools, etc. The names of some of these grasses where they breed during the dry season are given under the heading "host plants" discussed elsewhere in this paper. The broods overlap as different stages were observed at different times of the year. These observations on the prevalence of the pest were made in the province of Rizal from October, 1934 to June, 1936. It is most likely that the same observations apply to a more or less extent in other provinces where lowland rice is planted during the months of June and July.

DESCRIPTION

Egg.—Circular, somewhat flattened, light yellow, and has a smooth surface. Its diameter is about 0.5 of a millimeter. A day before hatching, the color becomes darker and two purplish dots appear, representing the eyes of the developing larva (Plate 2, figs. 1 and 2).

TABLE 13.—*Proportion of males to females.*

Date emerged	Number of males	Number of females	Remarks
1934			
December 11		1	Adults emerged from larvæ collected from the field.
December 12	1	2	
December 13	2		
December 16	1	1	
November 20		1	Adults reared from individual cultures.
November 26		1	
November 28	1		
December 5	1		
December 6	1		
December 7		1	
1935			
January 8	1	1	Adults reared from larvæ collected from the field.
January 10	1	1	
January 16		3	
January 17	2	2	
January 18	3	5	
January 21	8	7	
January 22	6	1	
January 23	3	4	
January 25	2	3	
January 26	2	2	
January 31	5	3	
March 4	3	3	
March 16	3	2	
March 18	6	3	
March 19	4	4	
March 20	3	2	
May 11	1		Adults from individual cultures.
May 12	1	2	
May 13	1		
May 14	1		
May 15	2	2	
May 16		1	
May 17	1		
May 18	1		
May 30	1	3	
May 31	1	3	
June 25	1		
June 26	1		
June 27	1		
June 29	1		
October 28		4	
October 29	6	2	
October 30	4	3	
October 31	1	2	
Total	84	75	



LEGEND

Period from seed bed to harvest of rice. (regular crop)

Dry season or period from harvest to seed-bed time.

Period when pest attacks rice.

Period when pest breeds on grass.

FIG. 1. Diagram showing the occurrence of the pest (*N. depunctalis*) throughout the year as observed in the Province of Rizal.

First instar larva.—About 1.2 millimeters long and 0.2 millimeter in diameter across the head; when newly hatched, it has a pale-cream color. The head is light yellow including the first thoracic segment and the eyes and mandibles are light purple. There are thirteen segments. The body is semitransparent, the tracheal tubes and tubular gills being visible with the aid of a magnifying glass. The head and first thoracic segment are sparsely covered with short hairs, or setæ (Plate 2, fig. 3.)

Second instar.—About 2.5 millimeters long and 0.5 millimeter in diameter across the middle of the body when newly molted; greenish throughout. The head is a little smaller than the body and light yellow. The markings, segmentation, and other characters are similar to those in the first instar.

Third instar.—About 5 millimeters long and 1 millimeter wide at its greates width. The color and markings are similar to those in the second instar. The tracheal tubes are longer than the third instar. The head, the first thoracic segment, and the anal segment are sparsely covered with short hairs.

Fourth instar.—About 8 millimeters long and 1.5 millimeters wide at its greatest width. The color and markings are similar to those in the third instar.

Full-grown larva.—About 14 millimeters long and 1.6 millimeters in diameter, pale green and somewhat transparent. The alimentary tract is green, and its contents are visible through the semi-transparent skin along the middle portion of the body. The head is about a millimeter in diameter, light brown including the first thoracic segment, and both parts are with brown spots. Both are sparsely covered with short hairs, or setæ. There are thirteen distinct segments, and the body is characterized by the presence of six rows of thin gills with tubes connected to the main trachea. There are five pairs of spiracles which, according to Maxwell-Lefroy (1909), are functionless, because the larvæ use the thin gills as breathing organs, instead (Plate 2, fig. 4).

Pupa.—About 5.5 millimeters long and 1.5 millimeters at its greatest diameter, and is creamy when newly pupated. The head is about 1 millimeter in diameter, and the developing eyes are purplish. Across the middle portion of the body, the diameter is about 1.5 millimeters. There are eight distinct abdominal segments with three pairs of prominent brown spiracles (Plate 2, figs. 7 and 9). The color of the pupa changes after the second

day, the eyes becoming ashy and the thoracic region, the wing pads, the legs, and the abdomen, silvery white. Antennæ, golden. Abdominal sutures are light yellow. The short and black hair-like projections are present at the anterior of the head.

ADULT

Female adult.—About six millimeters from the tip of the head to the tip of the abdomen, and has a wing expanse of from 15 to 16 millimeters. The general color is white with light brown and black markings on the wings.

The antennæ are about three millimeters long extending backwards, and rest on the wings. When the insect is at rest both pairs of wings are fully spread, or expanded. (Plate 3, fig. 1). Figure 3 in the same plate is the ventral view of the posterior abdominal segments of the female.

Male adult.—The male is usually smaller than the female, measuring from 4 to 5 millimeters from the tip of the head to the tip of the abdomen, and has a wing expanse of from 11 to 14 millimeters. Dorsally, the color and markings are practically similar to those of the female. Ventrally, including the last pair of legs, the color is darker than the corresponding part in the female. (Plate 2, fig. 2.) Figure 4, Plate 3 shows ventrally the posterior abdominal segments of the male.

Hampson (1896) describes the adult in detail as follows:

> Pure white. Forewing with the costa dark; a dark speck on a fulvous spot below middle of cell; a fulvous spot below origin of vein; 2 two black discocellular specks; an oblique fulvous band beyond the cell from costa to vein 5; a submarginal fulvous band, narrowing below vein 5, or often reduced to specks and obsolescent. Hind wing with dark discocellular speck, sinuous medial and post medial fulvous with a fine crenulate fulvous or dark-brown line just inside the margin and a more or less developed marginal series of specks.

NATURAL ENEMIES

The adult moths which fly at short distances among rice and grasses are often caught in spiders' webs or by birds and dragon flies. The circumstance minimizes the infestations to a certain extent.

The larvæ are parasitized by certain species of hairworms, possibly a species of the Family Mermithidæ (Plate 4, fig. 1). The mermithids live inside the body of the larvæ, while the latter are alive (Plate 4, fig. 2); but as soon as the contents of the hosts are consumed, the parasites leave the hosts and stay in the paddy water. The larvæ which are attacked by the hairworm never

develop into the pupal stage. Counts, made of the number of larvæ having the mermithid parasite under field conditions, show that out of the 28 individuals examined on October 20, 1935, 3 were parasitized. This gives a parasitism of 10.71 per cent. On October 31, 1935, another count was made and out of the 94 larvæ examined, 12 were parasitized, or a parasitism of 12.73 per cent. Seven more observations were made during the month of November, 1935 and the parasitism was from 2.63 per cent to 6.45 per cent. These percentages of parasitism give an average of 6.37 per cent (Table 14).

TABLE 14.—*Parasitism of rice caseworm larvæ by the hairworm.*[a]

Date	Examined	Not parasitized	Parasitized	Percentage of parasitism
1935				
October 20	28	25	3	10.71
October 31	94	82	12	12.73
November 5	16	15	1	6.25
November 5	31	30	1	3.22
November 5	33	31	2	6.06
November 6	38	37	1	2.63
November 7	31	29	2	6.45
November 10	22	21	1	4.54
November 10	21	20	1	4.75
Average				6.37

[a] Only larvæ with visible parasites were counted as parasitized.

The maggot (Plate 4, fig. 3) of a species of *Tabanus* fly (*Tabanus* sp.) was also observed feeding on the larvæ of the pest while the larvæ were in their cases (Plate 4, fig. 4).

So far, no egg parasite has been observed under field conditions, but in the laboratory, the imported parasite, *Trichogramma minutum* Riley, was tried on the eggs of *Nymphula depunctalis*. The parasites were observed to oviposit on the eggs thus exposed, and they turned black three days after the exposure, like other eggs attacked by the same parasite. No adult parasites were able to emerge, because the eggs dried up in the test tube. Unparasitized eggs of *N. depunctalis* never became black even if they did not hatch.

The common red ants (*Solenopsis geminata*) which build their nests in the paddy dikes attack the larvæ and pupæ of the pest, especially when the infested paddies became dry.

Prolonged drying up of the paddies is detrimental to the larvæ, and after strong rains and wind, the adult moths were often seen dead and floating on the water in rice paddies.

FIELD CONTROL TRIALS

(*a*) *Effect of draining the water from the infested paddies, application of kerosene on the paddy water, and dusting the leaves with calcium arsenate upon the larvæ.*—On October 16, 1935, four paddies which had almost the same degree of infestation were selected in the municipality of Binañgonan, Province of Rizal. The rice leaves of the first paddy were dusted with calcium arsenate including those of grasses growing among the rice plants. The powder was placed inside a cheesecloth bag. Then it was jarred slightly over the rice plants, and portion of the powder that escaped from the bag, adhered to both surfaces of the leaves. The use of cheesecloth bag in this particular case was possible to dust the nether surfaces of the leaves because the infested seedlings had their leaves almost straight upward as their tips were cut. (Plate 1). The second paddy was treated with kerosene by pouring it little by little on the water at the place where the water enters the paddy; the third was drained of its water; and the fourth was left untreated to serve as control. Leaf cases, supposed to contain larvæ were collected at random every day from the treated paddies and from the control. They were examined, and the number of dead larvæ were counted, discarding those that were parasitized and the leaf cases that were empty. The percentage of dead larvæ was computed from each set to determine the comparative degrees of mortality due to the effect of the different treatments. Observations were made for only two days, because it rained on the third day.

On November 3, 1935, another field trial was conducted in a different place. The same procedure was followed and partial result was likewise obtained, because rain affected again the experiment on the fourth day.

The results, obtained as presented on Table 15, show that the drained fields, as per counts done daily, had a mortality ranging from 30 per cent to 62.5 per cent with an average of 49.22 per cent. In the case of those paddies treated with calcium arsenate, the percentage of death from the daily observations ranged from 12.9 per cent to 63.88 per cent with an average of 31.65 per cent, and in the kerosene, treated paddies, the deaths ranged from 6.67 per cent to 64.28 per cent with an average of 23.06 per cent.

TABLE 15.—*Deaths of rice caseworm larvæ observed daily on the different treatments.*

Date of observation	Kind of treatment	Examined	Dead	Per cent
1935				
October 17 [a]	Water drained	90	48	53.33
October 18 [a]		89	54	60.67
November 4 [b]		20	6	30.00
November 5 [b]		16	10	62.50
November 6 [b]		38	18	47.36
November 7 [b]		41	17	41.46
Average				49.22
October 17 [a]	Cal. arsenate	30	13	43.33
October 18 [a]		36	23	63.88
November 4 [b]		16	4	25.00
November 5 [b]		33	9	27.27
November 6 [b]		40	7	17.50
November 7 [b]		31	4	12.90
Average				31.65
October 17 [a]	Kerosene	43	8	18.60
October 18 [a]		14	9	64.28
November 4 [b]		14	1	7.14
November 5 [b]		15	1	6.67
November 6 [b]		32	8	25.00
November 7 [b]		12	2	16.66
Average				23.06
October 17 [a]	Control	46	4	8.69
October 18 [a]		42	2	4.76
November 4 [b]		23	1	4.34
November 6 [b]		31	1	3.22
Average				5.22

[a] First trial, begun October 16. [b] Second trial, begun November 3.

The control paddies had a mortality of from 3.22 per cent to 8.69 per cent with an average of 5.22 per cent. Comparing the result obtained from the control paddies with the treated ones, the drained fields on the average daily counts had a mortality of 44 per cent over control; calcium arsenate 26.43 per cent and kerosene 17.74 per cent. The kerosene and calcium arsenate did not produce any burning effect on the rice plants.

Although the trials were disturbed by rains on the third day of the first trial and on the fourth day of the second—a factor which cannot be controlled under field conditions—yet the results obtained are encouraging on the ground that the treated fields gave a fairly good mortality over the control.

(*b*) *Approximate cost of application computed to a hectare.*—For the purpose of obtaining information on the approximate

expense that they may be incurred in the application of the above-named methods, the following computation is herewith presented;

(1) *Calcium arsenate.*—About 300 grams of this chemical were used in treating an area of about 100 square meters of three-week old rice plants planted about 15 centimeters apart. Basing on this quantity of calcium arsenate powder consumed to cover the said area, about 30 kilos of the chemical will be needed to dust one hectare. At the rate of thirty centavos (₱0.30) a kilo of calcium arsenate, the approximate cost of the chemical necessary for one application will be about nine pesos (₱9.00). Adding the cost of the four-hour labor which is forty centavos (₱0.40) at the rate of eighty centavos a day, the total expense will be nine pesos and forty centavos (₱9.40) a hectare.

(2) *Kerosene.*—About 150 cubic centimeters of kerosene were used on a paddy having an area of about 35 square meters. With this quantity, only a very thin film of the oil was formed over the surface of the water. Basing on this application, one hectare will require about 47 liters or about two and a half cans of five gallons each. The price of a five-gallon can of kerosene (Carabao brand) in the market was ₱1.80 at the time of the experiment so that the kerosene consumed cost about ₱4.62. Adding the cost of two-hour labor, which may be estimated at twenty centavos (₱0.20), the application cost about ₱4.82.

TRIALS WITH DERRIS ("TUBLE") POWDER UNDER LABORATORY CONDITIONS

Otanes(10), in mentioning the use of fresh derris roots againts rice stem borer (*Schoenobius incertellus*) in the Visayan Islands, Philippines, also suggested the possibility of the use of the same against the rice caseworm, *Nymphula depunctalis*.

Because of the availability of derris powder (this being manufactured by the Bureau of Plant Industry from the roots of derris plants, *Derris elliptica*) laboratory tests against the larvæ of *Nymphula depunctalis* was made possible. Derris is locally known as tuble, and the roots are used in the Islands and elsewhere for poisoning fish. The plants grow wild here, and up to this writing some farmers have started extensive plantings for commercial purposes.

The trial consisted as follows: Larvæ with their cases were collected from the field and placed in three separate containers with water having a volume of about 200 cubic centimeters each

and a surface area of about .11 square meter. Grass was also placed in each container. In the first container 22 larvæ were placed and 25 each in the second and the third containers. The first container was dusted with derris powder amounting to 0.2 gram; in the second 0.13 gram was used; in the third, 0.1 gram. The dust covered the surface of the water. With the 0.2 gram, all the larvæ died after about five hours, while in the last two treatments, it took about 22 hours before all the larvæ died.

In another trial the derris powder was put in the water after which the whole was stirred well before the larvæ were placed so as to get readily the soluble substance from the powder. The strengths used were 0.1 gram and 0.05 gram per liter of water. Twenty larvæ were used in each case. In the first application, all the larvæ died after about four hours and in the second, after about five hours. The derris powder used in all the above trials had a rotenone content of 3.09 per cent according to the analysis made by the Plant Utilization Division of the Bureau.

SUMMARY

The rice caseworm, *Nymphula depunctalis* Guen, (Family Pyralidæ) is one of the most important rice pests in the Philippines, and causes more or less serious damage. It attacks rice from July to November. From November up to the planting of the next crop, it feeds on grasses growing in water in the rice fields, in springs, pools, ponds, lakes, etc. Among the species of grasses where they were observed to feed on are *Panicum carinatum, Panicum colonum, Eragrostis interrupta, Paspalum scrobiculatum,* var. *vispicatum, Panicum stagninum, Panicum distachyum,* and *Panicum repens.* These grasses are common in rice fields in the Philippines.

Under laboratory conditions, the females laid eggs in one to four days after emergence, and the number of eggs laid by one female ranged from 3 to 103 with an average of about 52. However, when the females under observation died and were dissected, eggs were observed in their ovaries, the number ranging from 0 to 93. This gives the range of eggs produced from 47 to 103 with an average of about 81.

In this work, the eggs were observed to hatch after two to six days. After feeding for a day or two, the young larvæ were observed to enclose themselves with cases out of pieces of rice or grass leaves. The larvæ molted four times before pupating, each larva changing its leaf case usually before each molting.

The larval stage lasted from 14 to 20 days, with an average of 15.85 days. The pupal stage lasted from four to seven days, with an average of about five days.

The life cycle of the pest from egg to egg, under laboratory conditions, varied from 21 to 37 days, with an average of about 27 days.

The larvæ are attacked by a certain species of hairworm possibly of the Family Mermithidæ, with a parasitism of from about 3 to 13 per cent as observed in the field. The larvæ are likewise attacked by the maggot of a species of Tabanus fly and by the red ants (*Solenopsis geminata*).

Dusting the infested plants with calcium arsenate, draining the water from the infested paddies, and applying a thin film of kerosene over the water to control the larvæ gave encouraging results. Preliminary trials, under laboratory conditions, with derris powder also gave encouraging results, so that further trials in the laboratory and in the field are warranted.

ACKNOWLEDGMENT

The writer wishes to express his appreciation to Dr. Gonzalo Merino and Mr. F. Q. Otanes, Chief and Asst. Chief, of the Plant Pest and Disease Control Division, respectively, for their valuable suggestions and criticism while the work was in progress.

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ILLUSTRATIONS

PLATE 1

FIG. 1. Rice plant showing the nature of damage done by the larvæ of rice case worm. (*a*) Papery membrane left on the leaf as a result of the injury; (*b*) larva with its leaf case; (*c*) leaf case attached to the stem of rice plant wherein the larva pupates; (*d*) floating leaf case with larva inside. (× 10)

PLATE 2

FIG. 1. Grass shoot with eggs. (About natural size).
2. Egg much enlarged.
3. Newly hatched larve. (× 10)
4. Full-grown larva, lateral view. (× 10)
5. Full-grown larva, ventral view. (× 10)
6. Full-grown larva, ventral view. (natural size)
7. Pupa, ventral view. (× 10)
8. Pupa, ventral view. (natural size)
9. Pupa, lateral view. (× 10)
10. Pupal case showing opened portion where it is attached to the rice stem. (× 10)
11. Same (natural size)

PLATE 3

FIG. 1. Adult female, dorsal view. (× 10)
2. Adult female, dorsal view. (natural size)
3. Adult male, dosal view. (× 10)
4. Adult male, dorsal view. (natural size)
5. Posterior end of female's abdomen showing anal segment. (× 10)
6. Posterior end of male's abdomen showing anal segment. (× 10)

PLATE 4

FIG. 1. The mermithid (hairworm) parasite after it has emerged from the host. (× 10)
2. A larva, dorsal view, showing the mermithid parasite inside its body. (× 10)
3. The maggot of a species of Tabanus fly that preys upon the larva. (× 10)
4. Dead larva attacked by the predatory maggot. (*a*) Empty larva of the caseworm; (*b*) the predatory maggot. (× 10)

TEXT FIGURE

FIG. 1. Diagram showing the occurrence of the pest (N. depunctalis) throughout the year as observed in the Province of Rizal.

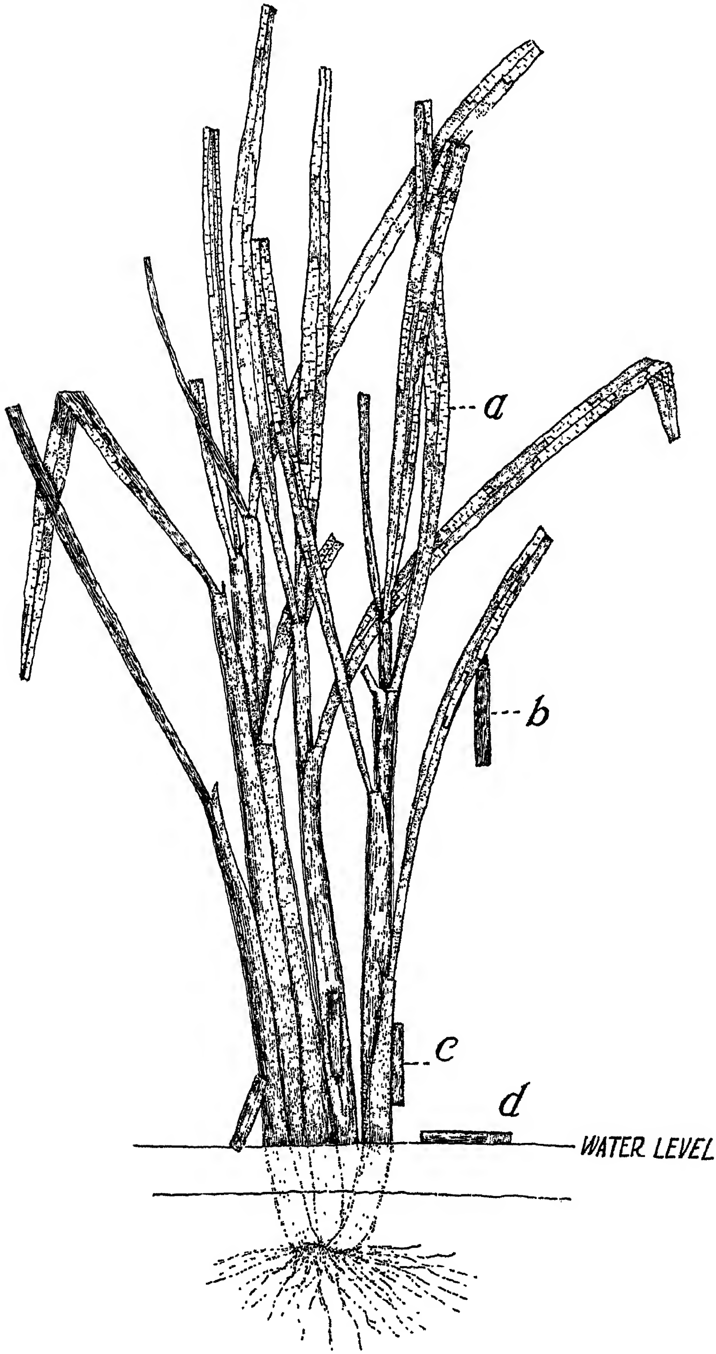
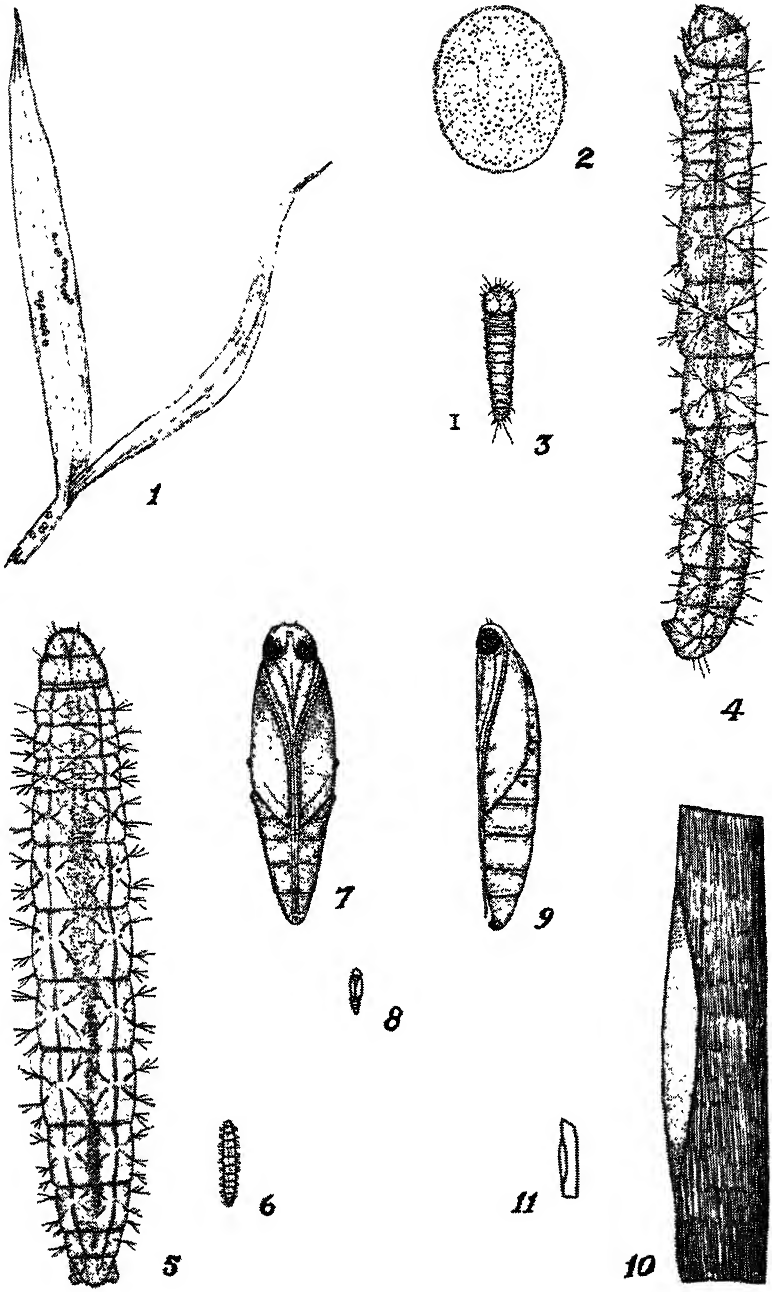


PLATE 1.



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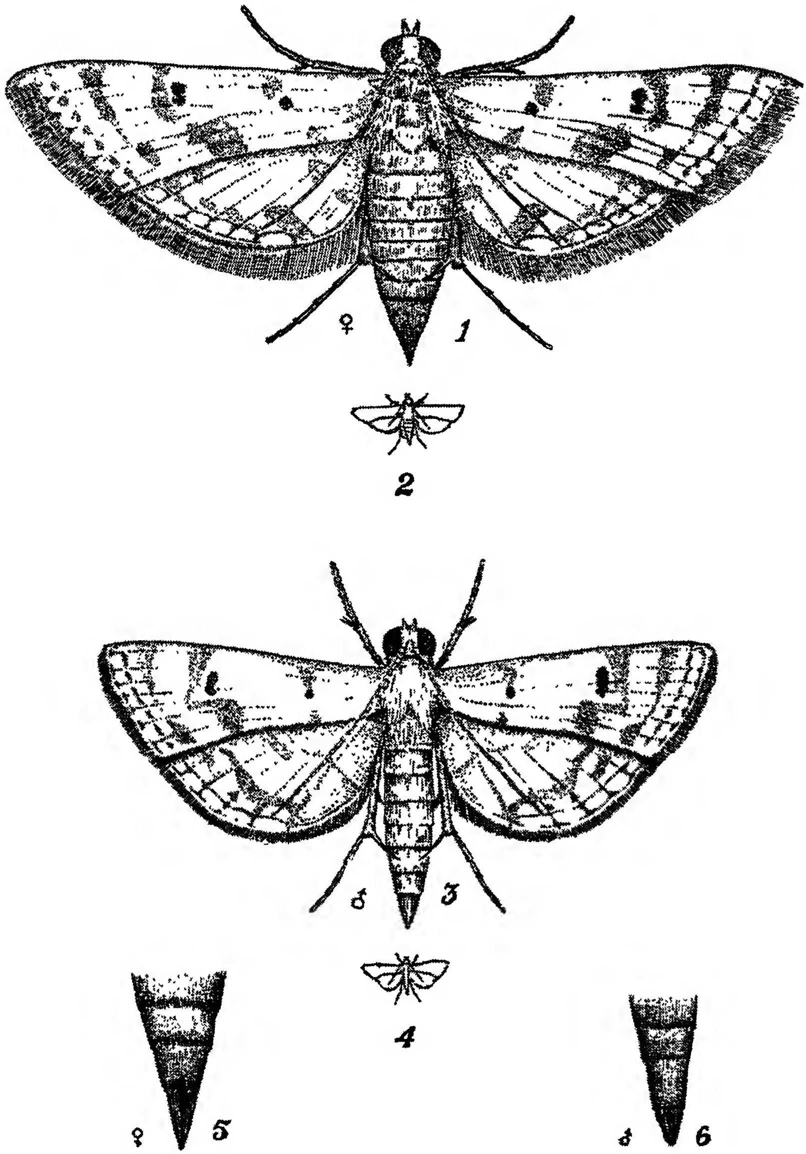

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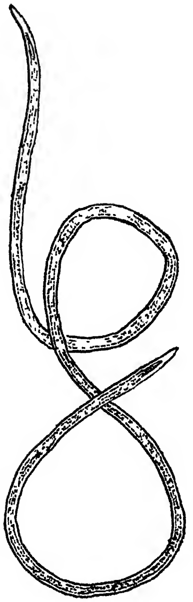

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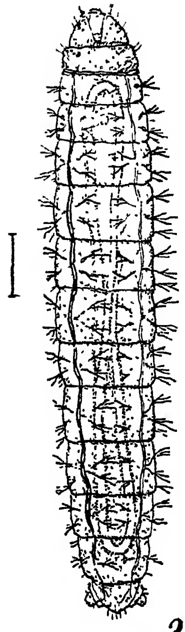

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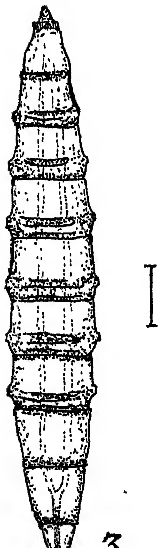

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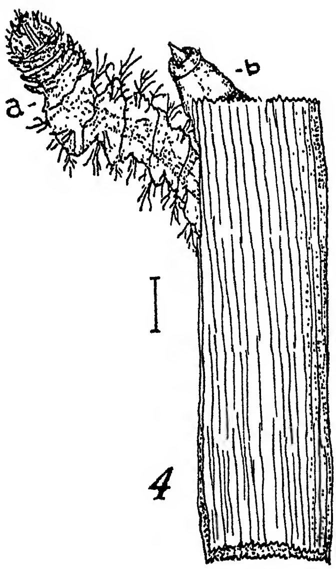

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PLATE 4.

NOTES ON THE HANDLING OF LANZON FLOWER BUDS AT HARVEST TIME

By SALUSTIANO S. GONZALES and FILEMON ABAYA
Of the Bureau of Plant Industry

FOUR PLATES

Up to the present time, the flower buds of the lanzones are the forgoten parts of the tree to most people insofar as care is concerned. A great number of these buds are destroyed by the notorious lanzon bark borers in almost all regions where the tree is grown. Still more buds are destroyed during harvests, for the simple reason that their presence on the tree at such a time is unknown to most of those concerned.

This article was thought of after several observations on the lanzon and on the methods of harvesting its ripe fruits in connection with a study now in progress on the control of the lanzon bark borers. The observation is of great importance especially when it is considered that the primitive method of gathering the fruits adversely affects future production, particularly the following crop, and as such the results of our study on the effect of the bark borers and that of the treatment given the trees to prevent future bark borer infestations on the trees' production, will be very much modified.

These notes, therefore, aim to acquaint those concerned with some facts about the lanzon flower buds and how their mechanical destructions may be minimized or completely averted especially during harvests.

THE LANZON FLOWER BUDS

The lanzon flower buds may appear singly or in groups of from 2 to 9. Each bud appears as a reticulate minute structure on the main trunk or branches of the trees either around the bases of the bunches of maturing fruits or on new locations. During the harvest season, most of those buds for the following or still later year's crop are about the size of a pinhead (Plate 1, fig. 2). Others may then be very much bigger, and if carefully examined, can be located without difficulty (Plate 1, fig. 2). These flower buds may develop earlier if weather conditions are

favorable or if there is a continuous supply of moisture especially during the dry season. Sometimes, also, depending upon weather conditions, many of the flower buds, especially those appearing before the dry season, either dry out or remain dormant for still another year.

Causes of destruction.—Although numerous flower buds are continuously being destroyed by the lanzon bark borers [1] throughout the year, more buds meet the same fate during harvests but from a different cause. We refer to the current methods of harvesting the fruits.

Orgas [2] gave warning about the manner of harvesting the crop, stating that in picking, the matured fruits should not be pulled off, as it injures the portion to which the bunch is attached and because it is within this region where the second set of fruits develops. He suggested that a sharp knife or shears should be used in clipping off the bunches. Many harvesters have already employed this improved method of harvesting the fruits, although there are still some who cling to the old practice of merely pulling off the bunches, thereby actually destroying the flower buds for the next crop which often are already visible at the bases of the bunches of mature fruits (Plates 2 and 3).

But a still greater injury to the following crop is generally done during harvests when the harvester climbs the tree with his hands and legs unaware of the numerous flower buds situated here and there on the trunk and on the upper portions of the tree, thus destroying many of these undetected future crops which, as has been stated above, are already visible during the months of harvests (September and October) particularly those that are around the bases of the clusters of fruits to be harvested.

The destruction of these flower buds will naturally result in less production the following year or season. Slipping of the feet and hands of the harvester during harvests or even their mere pressure are enough to destroy or completely detach these minute flower buds from the trees. This partly explains the common belief of lanzon grove owners that a year of good harvest is generally followed by a year of poor harvest. When the tree bears fruit heavily, the harvester naturally stays in the tree

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[1] A separate study on the lanzon bark borers is now being undertaken by the senior writer and another report covering this topic will be made as soon as results are complete.

[2] Orgas, Adriano M. The Lanzon (*Lansium domesticum* Jack). P. I. Dept. of Agriculture and Commerce. Bureau of Plant Industry Farmers' Circular No. 6.

longer than when the tree has few fruits. The more he moves about from branch to branch, the more are his chances of destroying the buds which will naturally result in small crop the following year; and because the trees will have only few or no buds to develop, so very few or no fruits at all will be harvested the following season. It follows then that the harvester should either stay in the tree only for a very short time and perhaps move less, or that he should not climb the tree at all, with the result that the trees are relieved of the usual ordeal it has to pass during harvest of good crops. The buds that are beginning to form at this time of the year will then have a good chance to develop for the next season.

RECOMMENDATIONS

To avert, therefore, this contributing factor, in the failure of the trees to produce normal crops every year, it would be well to eliminate, as much as possible, direct contact of the harvester with the trunk and the bearing branches of the trees during harvest time. This can be done by using ladders, preferably a portable self-supporting ladder as shown in Plate 4, when gathering the fruits. This will minimize or completely do away with the necessity for the harvester to step on the trunk or branches of the trees, thus saving the buds that would otherwise be destroyed if the fruits are gathered without the use of the ladder.

As was pointed out, the bunches should be clipped off with a sharp curved knife like the pruning knife or a shear, not merely detached with the bare hands. These suggested methods of harvesting are being employed in our bark borer control experiments with gratifying results.

ILLUSTRATIONS

PLATE 1

FIG. 1. A developing flower bud.
2. A cluster of flower buds.

PLATE 2

A developed flower bunch with flower buds at its base.

PLATE 3

A bunch of mature fruits with developing flower buds at its base.

PLATE 4

A portable self-supporting ladder that should be used in harvesting the fruits.

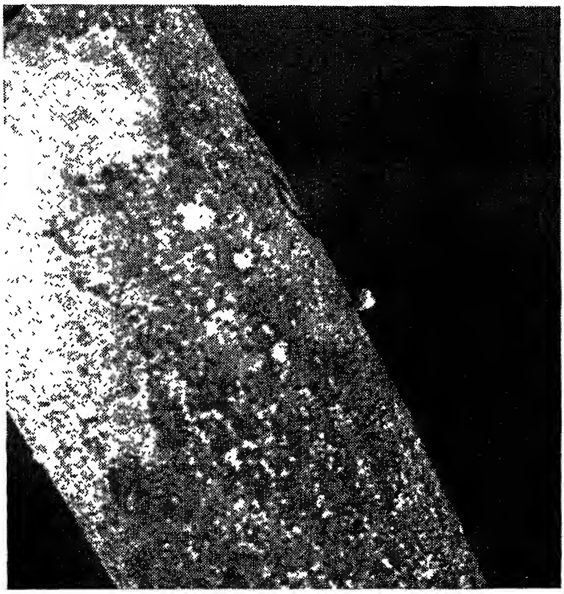

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PLATE 1.

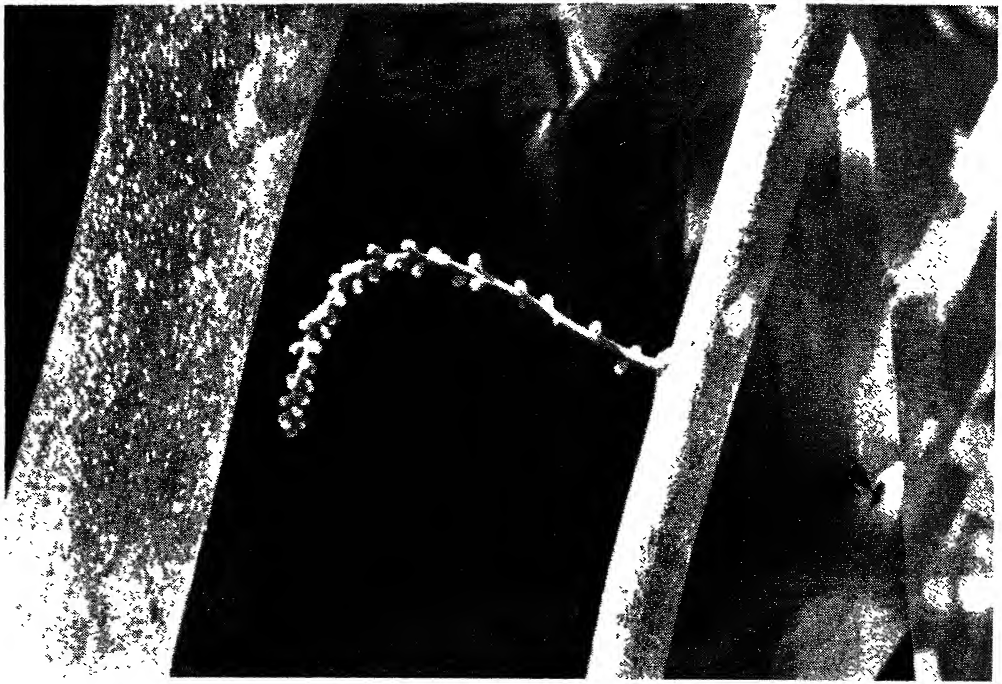

PLATE 2.

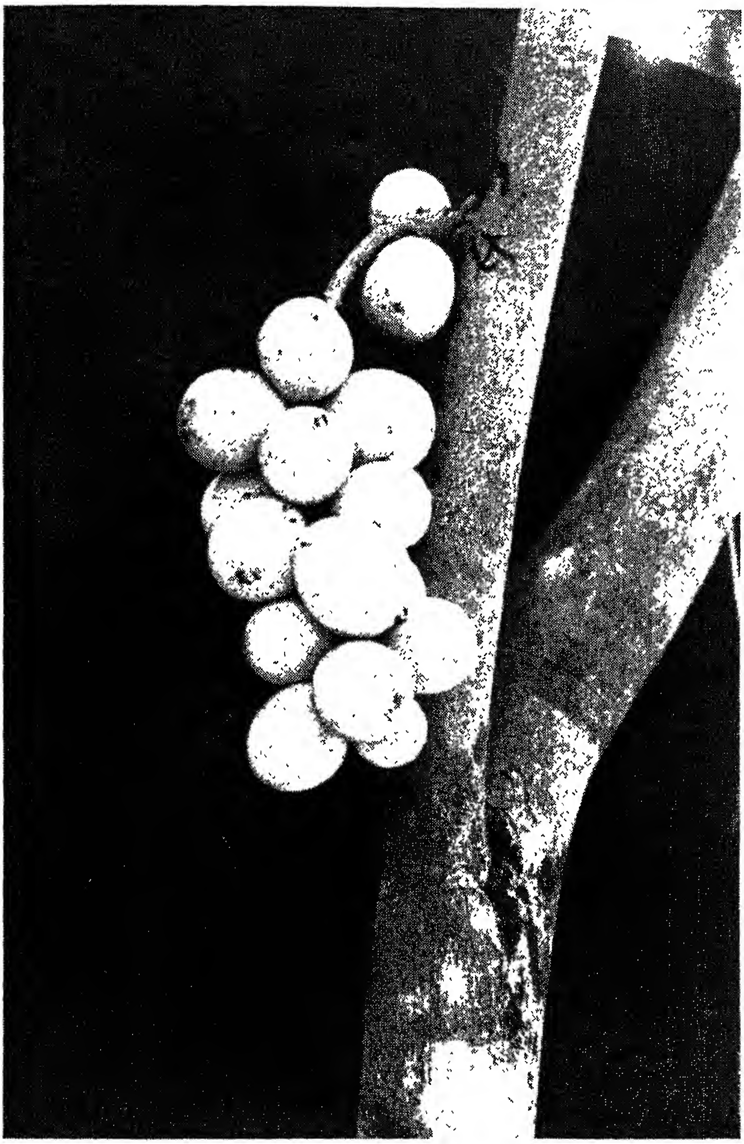

PLATE 3.

PLATE 4.

TRANSMISSION EXPERIMENT OF ABACÁ MOSAIC

(Progress Report No. 1)

By MELANIO R. CALINISAN

Of the Division of Plant Pest and Disease Control, Bureau of Plant Industry

THREE PLATES

In 1933, the writer(1) first observed the occurrence of the mosaic disease on abacá (*Musa textilis* Née) in the Province of Davao, Philippines. At first the disease appeared rather insignificant and no authentic report of its occurrence was known. Since 1933, however, it developed into one of the major diseases of abacá. The present paper includes the results of the transmission studies from diseased to healthy plants. Experiments were performed in the greenhouse of the Plant Pathology Laboratory, Bureau of Plant Industry, Manila, Philippines.

TRANSMISSION EXPERIMENTS

1. *Through soils.*—(*a*) On November 2, 1933, a series of experiments were conducted to determine if the abacá seedlings planted in "sick" [1] soil would develop the mosaic disease. Negative results were obtained.

(*b*) Similar experiment was performed by planting healthy abacá seedlings in sterilized garden soil mixed with decomposed mosaic tissues of abacá plant. Negative result was also obtained.

2. *By contact with diseased and healthy roots.*—(*a*) On November 3, 1933, healthy abacá seedlings, two months old, were planted in the same pot with mosaic plants in such a way that their roots were intertwined and in close contact with each other. Three healthy abacá seedlings and one diseased plant were planted in each of the four pots. After planting, all pots were covered with cheesecloth to exclude insects. No transmission of abacá mosaic was obtained after six months.

(*b*) *By contact with the leaves of healthy and mosaic plants.*—Three potted healthy abacá seedlings and three potted mosaic-infected plants were placed side by side in pairs in such a way

[1] "Sick" soil is meant soil taken from around and under the base of mosaic-infected abacá plant. This soil was taken from Davao.

that the healthy plant was paired with a diseased abacá. The leaves of the healthy plant were allowed to be in contact with the leaves of the mosaic-infected plant and rub each other periodically. This experiment was repeated in a series of trials. The result was negative.

4. *Through seeds.*—The writer failed to produce mosaic-infection by soaking for different lengths of time, seeds and seedlings of healthy plants, in diluted and undiluted juice expressed from the leaves, stems, corms, and roots of a mosaic abacá.

5. *Inoculations on the leaves.*—Goeffrey(3) used flat glass spatulas with success in his work entitled, "Some Experiments on Inoculating Methods with Plant Viruses and on Local Lesions." In an attempt to transmit the abacá mosaic disease to healthy plants the same procedure employed by Goeffrey was closely followed by the writer but negative result was obtained.

(*b*) Another method of artificial inoculation on the leaves which Fajardo(2) claims has given him a very high percentage of infection in his bean mosaic was also adopted. The method used consists of rubbing the upper surface of the abacá leaves with a small piece of cheesecloth containing a small quantity of sterilized fine sand mixed with a ground mosaic tissue until a more or less uniform abrasion is produced. Not a single case of mosaic infection developed.

(*c*) Another method employed is by placing over the leaf of healthy seedlings of abacá, mosaic leaf without detaching either from the mother plant and then by means of very fine insect pin pricking the infected leaf through the healthy leaf. The inoculated plants failed to take in the mosaic disease.

6. *Inoculation on the stem.*—The methods and technique employed in this work are modifications of what Sien(5) used successfully in his "new mechanical method for artificially transmitting sugar-cane mosaic."

(*a*) White No. 0 Asta insect pins (instead of No. 2) were used for inoculating healthy abacá plants. A slip of a mosaic leaf of about an inch wide and three inches long was inserted between the first and second leaf sheaths and held tightly with the thumb and forefinger of the left hand. Then with the pin in the right hand the leaf sheaths were pierced rapidly in and out at different parts passing through the mosaic leaf into the healthy tissue of the pseudostem. This method was repeated three or four times, each time a fresh mosaic leaf between the

different leaf sheaths was always used. In a series of trials, the results were all negative.

(*b*) Following the methods used by Stevenson(6) in his attempt to transmit the sugar-cane mosaic artificially, the writer inserted small bits of diseased tissues into the various parts of the pseudostem of healthy abacá plants, but in all the attempts made negative results were also obtained.

7. *Inoculation of the root.*—Both young and old abacá seedlings were dug up from the seed box and the roots washed thoroughly in running water. By means of fine sterilized insect pins, the young unfolded mosaic leaf was pricked through the healthy tissues of the old and young roots of the abacá seedlings. Then the inoculated plants were planted in pots containing sterilized garden soil. The results obtained were all negative.

8. *By means of hypodermic syringe.*—Injection by means of hypodermic syringe was also resorted to in an attempt to transmit the abacá mosaic to healthy plants. After extracting the juice from the old and young unfolded leaves of mosaic-infected plant and straining through a certain thickness of clean cheesecloth, the undiluted juice was taken up with a syringe and injected immediately into the pseudostem and leaf-axil of the healthy abacá plants. Eight potted plants were injected with the virus and four plants were injected with sterile water as control. Both the inoculated and controlled plants remained healthy after six months.

9. *Planting healthy abacá seedlings side by side with mosaic plants in the greenhouse.*—In May 1935, five abacá rootstocks taken from mosaic stools in Davao were planted in a plot inside the greenhouse.[2] All plants developed mosaic disease. Later, they were found heavily infested with aphids, *Pentalonia nigronervosa* Coq. (Plate 1).

(*a*) On September 27, 1935, five healthy plants (two Maguindanao and three Tan̄gon̄gon) were planted side by side with the mosaic plants in the greenhouse (Plate 3). On October 29, 1935, the first symptom of mosaic was noted on one of the plants of the Tan̄gon̄gon variety. On October 30, 1935, the other plant of the Maguindanao variety manifested the symptoms of the mosaic disease. On November 3, 1935, one plant of the Tan̄gon̄gon variety was infected with mosaic and on November 13, 1935, the other Tan̄gon̄gon variety showed the symptoms of mosaic disease. Only one plant (Maguindanao variety) failed to

[2] This greenhouse has a glass roof and metallic-cloth sides.

show the symptoms of mosaic. Examination of those infected plants revealed the presence of numerous aphids, *P. nigronervosa* Coq. No other insects were found.

(*b*) In line with the above experiment, one potted healthy abacá seedling of the Maguindanao variety was placed in close proximity with the mosaic-infected plants in the same plot in the greenhouse. (Plate 3). On October 30, 1935, this particular plant showed decided symptoms of mosaic infection (Plate 2, fig. 3.) The same aphids, *P. nigronervosa* Coq. were also found feeding on the plant and no other insects were found associated with it.

According to the results of the present experiments, *P. nigronervosa* seems to have some relation with the transmission of the abacá mosaic. However, the definite relationship of this insect with the disease may be established later by detailed experiments conducted under properly controlled conditions. In view of the presence of other sucking insects that have been frequently observed in considerable number feeding and breeding on both mosaic and healthy abacá plants in the field, it seems necessary that the possibility of these insects as vectors of the abacá mosaic should be investigated. The most important of these insects are the lace bugs, *Stephanitis* sp.[3] and a certain species of leaf hoppers. Experiments along this line are now underway.

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[3] The lace bug was identified by Mr. F. Q. Otanes, Chief, Entomology Section on November 26, 1938.

ILLUSTRATIONS

Plate 1

A portion of an abacá leaf infected with mosaic. Note the presence of brown aphids, *Pentalonia nigronervosa* Coq. (Natural size) feeding on the tender midrib. Photographed by the Bureau of Science, Manila.

Plate 2

Fig. 1. Potted abacá seedlings (Maguindanao variety) placed inside the greenhouse far from a plot where mosaic diseased abacá plants were planted. This plant is the control of Fig. 3. Note that at the end of the experiment this particular plant remains healthy.

2. This abacá plant (Maguindanao variety) was planted on September 27, 1935 in a plot in the greenhouse side by side with mosaic abacá as shown in Plate 3 marked X. On October 29, 1935, the symptoms of mosaic disease were first noted. The plant was dug up, planted in a pot, and photographed.

3. Potted abacá seedlings (Maguindanao variety). On September 27, 1935, this potted plant was placed side by side with mosaic diseased abacá in a plot inside the greenhouse. On October 30, 1935, the symptoms of mosaic disease appeared. Note also that there are plenty of aphids.

Plate 3

A plot in the greenhouse planted to five abacá rootstocks taken from mosaic-infected stools in Davao. All plants developed mosaic disease. The same plant marked X is shown in Plate 2, Fig. 2, after it has been infected with mosaic and planted in a pot.

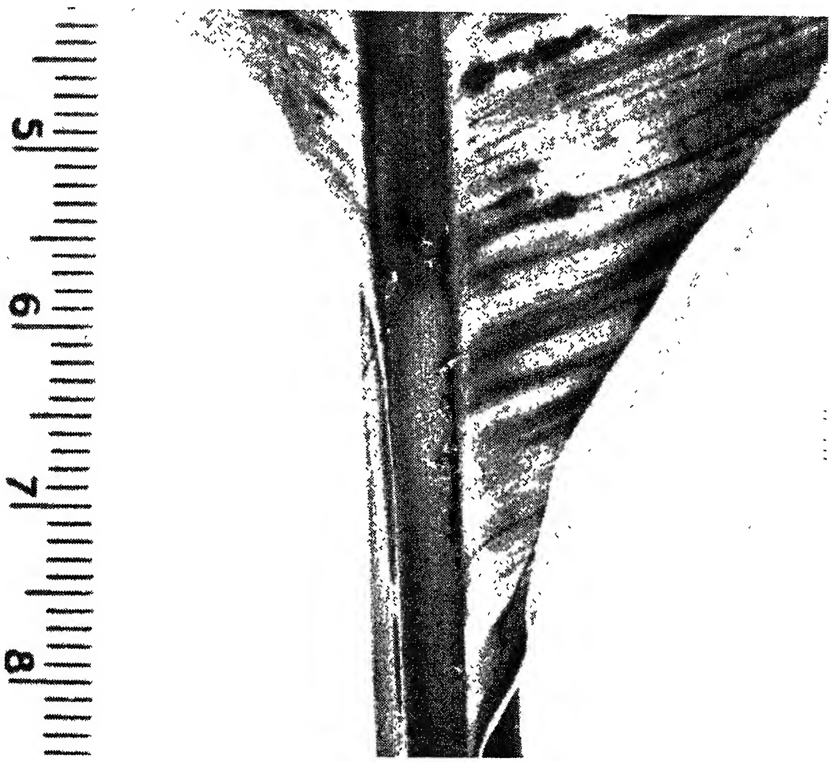

PLATE 1.

PLATE 2.

PLATE 3.

AVOCADO CULTURE

(Farmers' Circular 1)

By F. G. GALANG

Of the Horticulture Section Bureau of Plant Industry

FOUR PLATES

In its native home, tropical and semitropical North and South America, the avocado (*Persia americana* Mil. and *P. drymifolia* Ch. and Sc.) is an important food of the inhabitants. In the Philippines, however, it is still considered a luxury fruit since the present price is not within the reach of many. Of the many species and varieties of fruit trees introduced into the Philippines, none has gained so wide a reputation within a short time as the avocado. Although it is said to have been brought into the Philippines from Mexico in 1890, yet it was not successfully grown here until 1903 from planting materials received from Hawaii, Costa Rica, and the United States. The Bureau of Agriculture (now the Bureau of Plant Industry) began the distribution of avocado in the Philippines in 1913, and with the coöperation of the College of Agriculture of the University of the Philippines, it is able to produce many avocado trees bearing fruits in many provinces. Approximately 22,000 trees are now found growing in the Philippines, 4,500 of which are already bearing fruits.

VARIETIES

Avocado trees vary in habit of growth; some are tall with short lateral branches while others have spreading branches. The leaves are usually medium thick and leathery, and they vary in shape and size. The flowers are borne in compact panicles generally at the end of the twigs. The fruits are variable in shape, size, and color. The surface color of the fruit, when ripe, varies from light green to dark green, purple, brown, red, crimson, or maroon. The rind may be thin and delicate to thick and leathery and enclosing a large seed. The pulp is very nutritious, rich in fat, appetizing, with nutty flavor, and of a buttery consistency. There are three avocado races, namely, the West Indian, the Guatemalan, and the Mexican types. Each

of these types requires a different elevation for its development and possess different characteristics, as follows:

West Indian.—The fruit of this type has a poor shipping quality, loose-fitting, and with rather large seed. According to Stahl they contain from 4 to 7 per cent fat. The skin is medium thick and is always smooth and leathery. The seed coats are usually separated, and the cotyledons are rough on the surface. The fruit stems are short. The Philippine grown varieties under this type as the Pollock, Family, Cardinal, Wilson, Waldin, Wester, and Baldwin.

Guatemalan.—This type has a thick woody rind, producing dull, large, and rough fruits. The seed is small and invariably tight-fitting; the fruits are of good shipping quality, the meat of which is drier than that of the West Indian. The surface of the cotyledons is smooth. It contains more fat (from 10 to 13 per cent) but less carbohydrates. The fruit usually is borne on long fruit stem. The young leaves are frequently reddish or bronze in color instead of green. The Dickinson, Lyon, Tertoh, Taft, and Tumin are the varieties of this type already cultivated in the Philippines.

Mexican (*Persea drymifolia*).—The foliage is anise-scented, small, and sharp at the apex. The fruit is small with thin, smooth rind which generally adheres to the pulp and is of purplish black in color. It contains a higher percentage of fat (from 12 to 15 per cent). The seed is large with thin coats which are either separated or adhering to the cotyledons. The surface of the cotyledons is smooth. The varieties under this type that are already grown in the Philippines as Ganter and Puebla. Seeds of the Gottfried and Northrop were successfully introduced in 1924.

In planting avocado, one of the most perflexing problems is the choice of the right varieties, and this is due to a considerable variation in the productiveness of avocado trees. Some trees profitably bear fruits every year; others, only in alternate years; others do not bear any fruit at all. Many varieties fail to bear fruits satisfactorily owing to lack of pollination brought about by the failure of the flowers to open at the proper time or to the incompatibility of the pollen itself. Generally, fruit bearing in avocado will be more successful if compatible varieties are interplanted and if their flowers open at such time as will permit cross-pollination, or if self-compatible varieties are planted, the opening periods of flowers overlap. However, the varieties to be interplanted should have approximately the same flowering

time—early varieties should not be interplanted with late varieties and vice-versa. The midseason varieties can be interplanted with either the early or late varieties.

Of the hundreds of varieties now planted in the United States, not a single one has so far been selected that gives all the desired qualities. Each has some defects. And these varieties will have to be replaced eventually by a more desirable variety, or strain. In the Philippines, numerous seedlings and named varieties have already been imported and planted. Of those that have so far fruited, some are good, while others produce small fruits of poor quality. Moreover, many had failed to maintain themselves under local conditions. Altogether not less than one-hundred varieties and strains of avocado have already been introduced, out of which about forty varieties are surviving and seventeen are bearing fruits. However, according to the list of avocado varieties given in the 1929–1930 Annual Report of the California Avocado Association, there are 342 varieties, classified as follows: 62 Mexican, 78 West Indian, 152 Guatemalan, and 50 unclassified. In addition a score or more varieties and strains are fast developing in the United States and elsewhere. Therefore, aside from the varieties already found growing in the Philippines there are many more varieties and strains which merit further planting and introduction. Nevertheless, until new varieties, or strains, have proven to be superior and especially adapted to local conditions, the Philippine grown avocado varieties, which have fruited for several years, should be given preference in starting an avocado orchard. Of the many varieties that have been introduced and distributed, only a few have so far gained popularity. The Cardinal, Pollock, Lyon, Wester, Tertoh, Family, Cummins, Commodore, Cyrus, Quality, Douglas, Vega, and Miami have fruited successfully in Lamao, Bataan, and elsewhere in the Islands. But due to the limited extent of their trial, their selection should not be considered final. The Cardinal has predominated, however, probably because of its productive habit under certain soil and climatic conditions.

When selecting the varieties to be planted, one should be guided by the following points: The trees should be hardy, productive, regularly bearing, disease-and pest-resistant, early-or late-bearing; the fruit should be of good flavor, quality, and size; and the seed should be comparatively small. It should be borne in mind that the fat content does not indicate a good quality, for in the United States the most prized varieties are poor in this respect.

REQUIREMENTS

The avocado is distinctly tropical and subtropical in its requirements. There are now avocado trees growing in widely separated localities in the Philippines, and the behavior of these trees clearly indicates that the plant is at home in this country. In localities where the dry season is not too long, they thrive with very little attention. However, when the dry season extends to four or five months, they require some irrigation unless the soil moisture is within the reach of the roots during the driest part of the year.

The tree is not exacting in its soil requirements so long as good drainage is afforded. It is very intolerant of standing water, and cannot endure it for any length of time. Deeply and well-drained soil, which is rich in organic matter, is the best for avocado, but well-drained heavy soil of average fertility will also grow good avocado especially in moist regions. Any soil where citrus trees thrive will produce good avocado trees.

Like most other fruit trees, the avocado does not thrive well in places exposed to strong winds. Its leaves cannot quite resist excessively hot, dry winds. Besides, winds increase the evaporation of water which in turn may cause a heavy dropping off of immature fruits. Also the fruits are liable to suffer injury through rubbing against the branches or against each other, and the danger of the breakage of limbs, especially those heavily loaded with fruits, is increased. However, this is not a limiting factor in avocado culture, because it can be remedied by planting windbreaks in places where there is no natural protection from the winds. Windbreaks reduce the air movement and so diminish evaporation. Windbreaks should be planted around the orchard; if the plantation is large, windbreaks should be planted in every hectare lot.

The West Indian varieties are very tender, and are best adapted to low and medium elevations up to 900 meters above sea level. The Guatemalan varieties are rather intermediate, and have wider range of adaptability. They can be grown from sea level up to an elevation of 2,500 meters, but an elevation of not more than 700 meters is the best. The Mexican varieties are the hardiest with respect to cold weather, and have a wide distribution. They thrive best from 600 meters upward.

PROPAGATION

The avocado is propagated by seeds, by budding, grafting, inarching, or marcotting, but preferably by budding and graft-

ing. Inarching and marcotting are too laborious and expensive. Grafting sometimes gives a better result than budding. The grafted plants are oftentimes more vigorous than the budded ones. On the other hand, trees grown from seeds usually do not come true to type. The chances of obtaining a fruit of better quality than that produced by the parent tree are very slim. It is the experience of avocado growers that seeds are unreliable means of reproducing a variety. However, if seeds have to be depended upon for the propagation of avocado, the seed of some avocado varieties may be carefully halved so as to produce two plants from each seed. The resulting plants, however, should be given a reasonable dose of fertilizer in order to produce good growth. Generally the whole seed germinates earlier, and the resulting seedling is more stocky and has more number of leaves than the halved seed.

The first step in the production of budded or grafted trees is the raising of the stock plants. In the United States the varieties of the Mexican type are commonly used as stock plants because of their greater hardiness against frost than the large-seeded and hard-shelled varieties in spite of the greater amount of plant food in the seed of the latter. But this type possesses a wide range of variability, and caution should, therefore, be taken in using it as a stock plant in the Philippines. On the other hand, the West Indian seedlings, being generally more vigorous than the other types, may prove good stock plants at lower altitudes in the Philippines, although they were proven less successful as scion for the Mexican stock. The Guatemalan type will succeed both the West Indian and the Mexican stocks. This type is vigorous and thrifty, but somewhat tender although less so than the West Indian. Fuerte, a hybrid between Guatemalan and Mexican types is much used as stock plant in the United States nowadays.

As the seed of the avocado loses its vitality quickly, it should be planted while it is still fresh. And if the seeds cannot be planted at once, they should be stored in properly moistened sand, sawdust, charcoal, or sphagnum moss. The seeds may be planted directly in bamboo pots or in seed beds with the pointed end up. About one-fourth of the seed should be left exposed so that the resulting sprouts can be thinned out, leaving the strongest one. Set the seeds 40 or 50 cm apart in the seed beds. In potting, the soil should contain one-third each of sand, loam, and well-rotted compost. If sown in seed beds, the soil need not be so rich—a sandy loam soil being sufficient. It is sometimes advis-

able to grow the seedlings for budding or grafting in the seed beds although it will require more labor to remove them properly when transplanting them in the field. Seeds should not be allowed to dry out, otherwise they will lose their viability.

Budding or grafting is done in the same way as in citrus or other fruit trees. It can be done any time the stem of the stock plants has attained the size a little larger than a lead pencil provided it is not raining and that the seedlings are in condition, that is, the sap is flowing freely. The scion should be selected from the best tree of the desired variety, should be well matured, preferably from twigs which are just ready to send out a new growth, and should contain plump and well-developed buds.

Avocado stem is very brittle so that in forcing the bud to grow, a notch should be made of a few inches above, the bud instead of cutting the stem half-way into the wood of the stock for lopping as in the case of other fruit trees. In lopping never bend the stock as in other fruit trees in order to avoid a premature breaking. When the scion is already well advanced, the top of the stock bay be cut off entirely about 10 centimeters from the bud. After the bud has grown to a length of about 25 cm., the stock should be cut off clean just above the union of the stock and the scion, and the cut surface should immediately be painted with white lead or other suitable materials. This will protect the wood from decay.

PLANTING

When the plants are about 50 cm. high or more, they can be transplanted in the field at the beginning of the rainy season, at a distance of about 8 to 10 meters apart in holes large enough to accommodate the plants. Set the plants as deep as they grow in the nursery, and use good surface soil for refilling the holes. The soil should be packed firmly around the plant. It is well to pour in water while firming the soil. If water is available, planting may, of course, be done late in the rainy season, and even during the dry season. In transplanting, great care should be taken so as not to injure the root system which is very delicate, and the roots should never be exposed to dry or else the plants will die. To avoid the least injury to the roots, the plant should be dug from the nursery with a ball of earth. In planting balled trees, it is necessary to remove the sack or wrapping materials from around the ball of earth as the sack will decay in due time. However, to facilitate the rotting and the

penetration of water, two or three cuts should be made at the sides with a sharp knife. Split and remove the pot in transplanting the potted plant. Cut one-half of the leaves or young twigs of the plant previous to transplanting. The newly transplanted plants should be watered and mulched from time to time as may be necessary. In watering, a basin should be made around the tree to hold the water. Shedding the newly transplanted plant is necessary if planting is made during the dry season. Care should be taken that varieties are planted together which will provide pollen for each other at the time when each is ready for pollination.

ORCHARD MANAGEMENT

A modern fruit tree orchard should be well cultivated, irrigated, fertilized, cover-cropped, pruned, and mulched from time to time. The cultivation of young avocado orchard is done in the same way as in citrus, that is, deep plowing is advisable at the beginning; but when the trees are already big, deep cultivation should be avoided as much as possible, otherwise there is danger of destroying part of the root system and exposing the soil. At this stage the tree can be kept clean by occasional hoeing of the ground near its trunk. Mulching the trees and planting cover crops between the spaces are beneficial for the upkeep of the trees, since both prevent soil erosion and replenish the nitrogen and organic matter of the soil. Legumes have the power of gathering free nitrogen from the air and storing it in their nodules, and are, therefore, more valuable as cover crops than non-leguminous plants.

In order to get the most profit from the trees, it is always a good practice to maintain the fertility of the soil. To accomplish this, fertilizers should be applied regularly to bearing trees. There is a wide diversity of soil in the Philippines so that to give advice regarding the kind and amount of fertilizer without knowing the condition of the soil is almost futile. However, the kind of fertilizer needed by avocado is probably not very different from that needed by other fruit trees although the amount may differ. And in the absence of experimental data no definite and specific information can be given. The condition of the tree and of the soil should be the determining factor as to the kind and quantity of fertilizer to be used.

A young tree requires very little, if any, commercial fertilizer until it begins to bear fruit heavily. Animal and poultry manures and nitrogenous commercial fertilizers are, however, beneficial

to young avocado trees. A complete fertilizer which is low in nitrogen and high potash is good for fruit-bearing trees. In the United States a mixture containing 5 per cent nitrogen, 7 per cent phosphoric acid and 2 per cent potash, the nitrogen being derived from organic materials, has given good results on young trees when applied at the rate of one pound per tree, three or four weeks after planting, and 8 to 10 pounds on five-year old trees. The percentage of potash is increased while the trees come into bearing—5-8-3 or 6-6-3 in spring; 4-8-10 in the fall, and 4-7-5 or 5-5-5 in summer.

As a general rule, avocado requires little or no pruning at all after the tree is properly established. However, inasmuch as the avocado plant is naturally weak and brittle, the pruning of forking branches and shortening of young and spindling twigs may be done to strengthen the stock and the framework of the growing tree. This is to be done at their dormant stage. The mere pinching of undesirable shoots may induce the growth of other buds where an extension is needed in order to make the trees more or less symmetrical in growth. Tall growing trees should be pinched back. Again, some thinning of the branches should be done from time to time so as to permit sunlight into the inside foliage. Of course, any heavy pruning should be avoided, as this will greatly accelerate the vegetative growth and delay the fruiting period. Only dead and undesirable branches should be removed after the fruits have been harvested. All wounds should be painted with white lead or other suitable materials to avoid rotting.

In places where there is a uniform distribution of rainfall, the avocado need not be watered at all, but in places where there is a prolonged dry period, watering is necessary unless the ground water is high or is within the reach of the roots. The water may be distributed in the way which is most convenient, economical, and effective. The furrow system of irrigation should be practised on big plantations whenever it is practicable for the sake of economy, and the bucket system may be used for watering the individual trees around the house. Where there is lack of water in the soil, the trees may shed much of their foliage, flowers, or fruits.

It is often advisable to top-work undesirable trees in the orchard to a good variety. This can be done by cutting the tops back including the big branches. Of the numerous sprouts which appear, only a few good ones should be left for budding or grafting with selected scions. The cut surfaces and the trunk

should be painted and whitewashed in order to protect them from decay and sunburn.

PESTS AND DISEASES

There are comparatively few insect pests and diseases which at present affect the avocado in the Philippines. Among the insects, the borers and the scale insects, including mealy bugs, are found destructive to our avocado trees. Other pests are the thrips, caterpillars, and white ants.

The borers are found to attack the trunk, pith, and twigs. They work their way downward destroying all growth thereby, and may eventually kill the tree. Lime wash may lessen the infestation.

The caterpillars attack the leaves and flowers. They can be controlled by spraying either with lead or calcium arsenate.

The thrips attack the flowers, but they can be prevented by dusting with pyrethrum, derris powder, or tobacco dust.

The scale insects suck the sap of twigs, leaves, and fruits. Heavy infestations weaken the tree, and sometimes cause premature falling of fruits. Oil emulsions and soap suds are usually effective in controlling the scales.

The important diseases of avocado are die-back and anthracnose. The anthracnose is a disease of the leaves, bark, and fruit. The affected portion turns black with sunken spots, usually circular in form. It can be controlled by spraying with Bordeaux mixture. The infected parts should be cut and burned.

The die-back is a disease of the twigs. The infected parts become dry. It can be prevented by spraying the trees with lime sulphur or Bordeaux mixture. These sprays should be applied periodically once every two weeks at least as the new flushes appear until they mature.

Other diseases of minor importance which may also be controlled are the scab and the leaf spots.

HARVESTING AND YIELDS

The avocado season in the Philippines is from January to March and from June to September, depending upon the climate of the locality. In humid districts the season is rather early. There are, therefore, only two short periods in the year during which avocado fruit is not obtainable in the market—from April to May and from October to December. However, by planting varieties which fruit at different times of the year, it is possible to produce avocado fruits all the year round. In the United

States the Fuerte variety is said to be fruiting from November to May; Verde from March to May; Puebla from November to December; and Taft from May to November.

Avocado trees grown from seedlings begin to bear fruits when about four to eigth years old, six being the average. On the other hand, vegetatively grown trees sometimes begin to bear fruit the first year in the nursery. At this age, however, and probably up to three years, they should not be allowed to fruit at the expense of the future growth and vigor. The annual yield of a full-bearing tree ranges from a few to 500 fruits—sometimes from 800 to 1,200 fruits. An average of 500 fruits a year per tree is considered a fair yield. Generally the yield varies from one season to the next, partly depending upon the size of the previous crop, rainfall, winds, and the conditions of the tree at the flowering season.

The avocado fruits are very perishable and should be handled with care. In harvesting, the fruits should be carefully clipped off, leaving a short stem on them for handling purposes. A fruit picker provided with a knife similar to that one used in picking the mango fruits should be used in harvesting the fruits of tall growing trees. Furthermore, the avocado should be harvested when fully matured, and not allowed to ripen on the tree. The maturity of the fruit is indicated by its color. For example, the appearance of reddish streaks in the case of purple fruiting varieties and the change of color from green to a lighter green in the case of green varieties are indications of maturity. In the thin-skinned forms the ripeness of the fruit can be determined by external pressure, but in the very thick-skinned varieties this cannot be done. The ripeness of the fruit of the latter varieties can be determined by the stems when it is easily pulled out of the fruit, and when a toothpick can be easily pushed through the stem it indicates that the fruit is ripe enough for eating. If the fruit is picked before reaching maturity, its flavor is poor, while if left too long on the tree, the keeping quality is impaired. The fruits should be placed in a basket or box lined with packing materials, such as dried straw, banana leaves, etc., when intended for short distance shipment; when the fruits are to be shipped long distances they should be wrapped individually with soft tissue paper.

USES

The avocado fruit is rich in fat and protein but low in sugar content. Its oil is similar to olive oil and can be used for the

same purposes. It has been known in countries where avocado has been long grown that its fruit is a wholesome and highly digestible food. Wolfe and others said that an ounce of avocado contains about 73 calories, which is nearly three times that of banana, one and a half times that of beefsteak and other meats, and three times that of several kinds of fish. And because of this and its low carbohydrate content it is a good food for diabetic people. Its iron content is about three times that found in other common fruits and, therefore, it is a good food for anemic people.

In the Philippines the fruit is eaten with sugar and milk, or in frozen form, or as ice-cream ingredient. Few people eat the meat offhand. In the United States it is extensively used as a salad fruit because of its delicate, nutlike flavor, and its smooth, buttery consistency. The avocado should not be considered merely as a salad fruit but as a substantial food which may be used in a great many combinations. For it is also eaten offhand, with the addition of lime or lemon juice, or salt, or sugar only. Mashed and seasoned, the meat is used as sandwich filling, or is spread on salted crackers. Often it is also added to soup just before serving. A number of recipes on how to eat avocado fruit has been published from time to time.

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ILLUSTRATIONS

Plate 1

An avocado tree top-worked to 15 varieties at the Lamao Horticultural Station, Limay, Bataan. The scions fruited at the age of 1 year and 7 months.

Plate 2

Budded Cardinal avocado at the Lamao Horticultural Station, Limay, Bataan.

Plate 3

Budded Pollock avocado at the Tanauan Citrus Experiment Station, Tanauan, Batangas.

Plate 4

Avocado seedlings grown from whole and halved seeds.

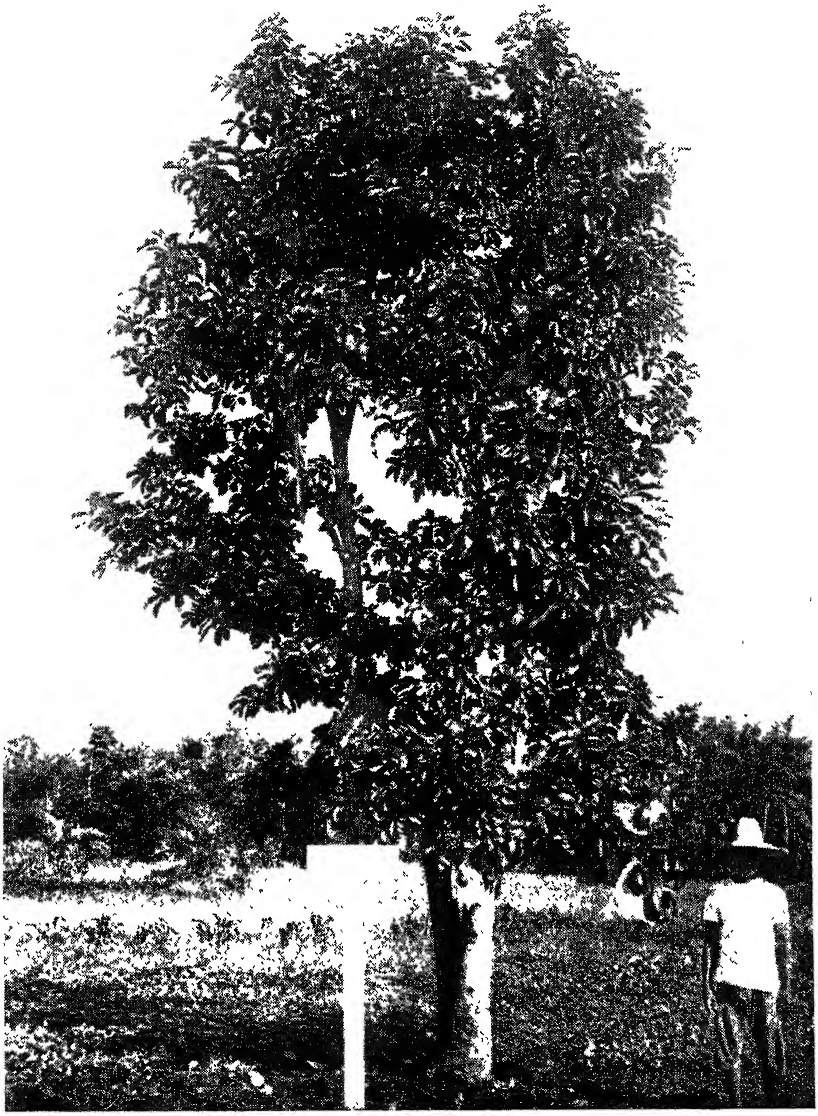

PLATE 1.

PLATE 2.

PLATE 3.

PLATE 4.

THE THREE DESTRUCTIVE DISEASES OF ABACÁ IN DAVAO (BUNCHY-TOP, MOSAIC, AND THE VASCULAR DISEASE) AND THEIR CONTROL

(Farmers' Circular No. 35)

By MELANIO R. CALINISAN
Assistant Plant Pathologist, Bureau of Plant Industry

THREE PLATES

At present, there are at least three very destructive diseases of abacá, or Manila hemp, which are threatening the abacá industry in the province of Davao; namely, (1) the vascular disease of abacá, or abacá wilt (Plate 1), (2) the bunchy-top (Plate 2), and (3) the mosaic (Plate 3).

The bunchy-top, it may be recalled, is responsible for the total destruction of the abacá industry in Cavite, Batangas, and Laguna and partly in Mindoro. In Cavite alone, 12,843 hectares of abacá plantation were practically wiped out by the bunchy-top disease within a period of 10 years. The bunchy-top was discovered in Davao since 1931; the mosaic, in 1933; and the vascular disease, in the later part of 1936. Continuous eradication measures against the bunchy-top conducted by this Bureau since 1931 up to date saved the industry from complete ruin.

Inasmuch as the aforesaid diseases have the tendency to spread far and wide, it is imperative that immediate action be taken in plantations where these diseases are present.

VASCULAR DISEASE

Symptoms.—The symptom of this particular abacá disease is manifested by the presence of dark-brown morbid portion at the base of the plant close to the surface of the ground (see Plate 1). The blackening or rotting presumably works inward and upward, eventually affecting the leaves of the plant. The older leaves turn yellow and the growth of the youngest ensuing leaf is retarded. Occasional cracking of the leaf sheath at the base may be observed. A longitudinal section and cross-sections of the diseased plants reveal the presence of reddish pink to crimson-like discoloration of the fibrovascular tissues of the corns and

stalks which at times may extend up to the petioles of the leaves. To all appearances, this particular disease is very similar to, if not identical with, the banana wilt, or Panama disease. The abacá plants are attacked, regardless of age.

Cause.—Nothing definite is as yet known about the real cause of the disease. However, in wilted or dead plants, a fungus very similar to that causing banana wilt and known as *Fusarium cubense* and a weevil, *Odoiporus paganus* Uichanco, are associated. Oftentimes, pure culture of bacteria were isolated from the corm, pseudostem, and from the very tip of the discolored tissues of the petioles of the leaf. Further investigations are in progress to determine the definite cause.

BUNCHY-TOP

Symptoms.—The term "bunchy top," although self-explanatory is meant more than a mere bunching of the aërial portion of the abacá plant (see Plate 2). The growth is arrested. The petioles arise apparently from the same plane on the stalk. The leaves assume a more or less rossette arrangement. The affected plants are stunted, or dwarfed. The leaves gradually become shorter and narrower until finally they become almost devoid of the leaf blade. The leaves tear along the margin and usually curl toward the inside. The crowding of the leaves is very conspicuous in the advanced stage of the disease.

Cause.—It is definitely known that the bunchy-top disease of abacá is caused by a virus which is present in the sap of a diseased plant. This virus is so minute that it cannot be seen under the most powerful microscope. However, one thing is certain: the virus is carried and transmitted from diseased to healthy plants by the dark-brown aphid, or plant louse, *Pentalonia nigronervosa.* Before these aphids can transmit the disease to healthy plants, they have to feed first on the diseased abacá by sucking the sap which contains the virus in the same manner as a mosquito (Anopheles) carries and transmits malaria from a malaria patient to healthy persons. No other means of transmission is known.

MOSAIC

Symptoms.—The most typical characteristic symptom of abacá mosaic is the mottling of the leaves (Plate 3). The mottled areas consist of dark-green and yellowish pale-green patches which are plainly visible on both surfaces of the infected leaves, petioles, and sometimes, although less frequently, on the pseudostem.

Cause.—In the case of abacá mosaic, it is believed that this disease is also caused by a virus which may be transmitted from diseased to healthy plants by the same sucking insect, the aphid, or plant louse. The mosaic, like the bunchy top, is also carried over to the new plantation by planting either diseased suckers and rootstocks or those taken from diseased stools.

SUGGESTIONS FOR CONTROL

The old adage, *"an ounce of prevention is worth a pound of cure,"* is decidedly applicable to these three very dangerous diseases of abacá.

Where the bunchy-top, the mosaic, and the vascular diseases are not yet present, it is important to practice strict exclusionary measures. In this connection it is necessary to prohibit the movement of propagative materials (suckers and rootstocks) of abacá and banana or any other plant belonging to the genus *Musa* from localities infested with these dangerous diseases to regions where the same trouble is not yet known to occur. The risk lies in the fact that such propagative materials may harbor the disease or may carry with them the virus-bearing aphids which are the principal carriers of the bunchy-top and presumably of the mosaic. It should be borne in mind that these insects or diseased plant parts, are liable to be carried from disease-infected districts to a disease-free locality through certain means, like soil, leaves, and leaf sheaths of abacá and banana which are often used for wrapping propagative plant materials or any product for shipment.

If the bunchy-top, the mosaic, and the so-called vascular diseases appear in any abacá-growing district despite rigid quarantine measures, there is no other alternative but to take immediate steps to eradicate them. The method is quite simple, and what has been proved with success to control the bunchy-top may also be employed effectively to control the mosaic and the vascular diseases.

If the disease is still localized, the whole plantation should be surveyed row by row to locate all plants infected with any of the three diseases. As soon as a bunchy-top or a mosaic hill is located, pile a big heap of dried abacá leaves and debris on the base and on top of the plants between the petioles of the leaves and burn them. Necessary precaution should be taken to give the aphids no chance to escape and migrate to neighboring healthy plants. After the burning is done, the plants should be dug out including the corm and chopped into small pieces right on

the same spot. They should be burned completely for the second time by using dried abacá leaves or other combustible materials. The first burning is employed to kill the aphids, the second to destroy the sources of infection.

In the absence of more definite information about the nature and real cause of the vascular disease, it is believed, that constant roguing and burning of all diseased plants *in situ* as fast as they appear would check the rapid progress of the disease. The above procedure should be done until the whole plantation is thoroughly surveyed and all diseased plants are removed and properly disposed of. In this way the disease may be controlled entirely.

If, on the other hand, the bunchy-top, the mosaic, and the vascular diseases are already widespread in a more or less epidemic form, it is suggested that all mature stalks free from disease be harvested or stripped, and then the entire plantation should be burned. Dig out the plants as previously described and destroy them completely. Clean the field thoroughly and plant rice, corn, potato, or any other temporary crops, like soybeans and other crops suitable to the place. After a year or two, plant abacá anew, if so desired. Be sure to get suckers or rootstocks from healthy and vigorous plants only from districts absolutely free from any of the three mentioned diseases. Whenever resistant varieties are available, they should be planted in lieu of the highly susceptible ones.

With this practice, coöperation between all the abacá growers is essential in controlling these three dangerous diseases of abacá. Everybody should do his bit for no matter how intelligently and seriously a farmer sets himself down to his task, he is helpless if his neighbors are indifferent. A community spirit will help wipe out these troubles and save the industry.

For further information consult the Bureau of Plant Industry, Manila or local office of the Provincial Agricultural Supervisor and work with them to control the disease.

ILLUSTRATIONS

PLATE 1

Abacá plant, Maguindanao variety, attacked by the vascular disease. Note the rotting or blackening at the base of pseudostem and the wilting of the leaves.

This specimen was collected from Mindanao Reclamation Co., Tongkalan, 1,750 ft. above sea level.

PLATE 2

A typical illustration of young abacá plants infected with the bunchy-top disease. Note the bunchy appearance of the leaf and the stunted growth of the plant.

Photographed by Mr. Kojima of the Ohta Development Co., at Dacudao Plantation, Davao.

PLATE 3

Young abacá suckers infected with mosaic disease. Note the mottled areas consisting of dark-green and yellowish pale-green patches on the leaves, petioles, and pseudostem.

PLATE 1.

PLATE 2.

PLATE 3.

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3. Lipa Coffee-Citrus Station, Lipa, Batangas
4. Tanauan Citrus Station, Tanauan, Batangas
5. Granja Sugar-Cane Station, La Granja, Occidental Negros
6. Gandara Seed Farm, Gandara, Samar
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2. Halcon Rubber Substation, Baco, Mindoro
3. Gingoog Lanzon Reservation, Gingoog, Oriental Misamis
4. Mandaue Seed Farm, Mandaue, Cebu

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Manuscripts intended for publication in the Philippine Journal of Agriculture should be sent to the Chief, Publications Division, post-office box 613, Manila, Philippine Islands.

One hundred separates of each paper published in the Journal are furnished to the author without charge. Additional copies may be had at the author's expense if ordered when the manuscript is submitted for publication.

The journal is issued quarterly. The subscription price is 2 pesos (Philippine currency) or 1 dollar (United States currency) per year in the Philippine Islands and the United States and territories; 2 dollars (United States currency) in foreign countries. Single copies are sold at the same rates.

Subscriptions should be sent to the Chief, Publications Division, Department of Agriculture and Commerce, post-office box 613, Manila, P. I.

Publications sent in exchange for the Philippine Journal of Agriculture should be addressed: Scientific Library Division, Bureau of Science, Department of Agriculture and Commerce, post-office box 774, Manila, P. I.

Vo[illegible] FOURTH QUARTER, 1938 No. 4

The Philippine Journal of Agriculture

PUBLISHED QUARTERLY BY
THE DEPARTMENT OF AGRICULTURE AND COMMERCE

MANILA
BUREAU OF PRINTING
1938

24092

DEPARTMENT OF AGRICULTURE AND COMMERCE

Hon. EULOGIO RODRIGUEZ, A.B., *Secretary*
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THE PHILIPPINE JOURNAL OF AGRICULTURE

Published quarterly by the DEPARTMENT OF AGRICULTURE AND COMMERCE
Editorial Offices: DIVISION OF PUBLICATIONS, Oriente Building, Plaza Binondo, Manila

[Entered at the Post Office at Manila, Philippines, as second-class matter]

The Philippine Journal of Agriculture

VOL. 9 FOURTH QUARTER, 1938 NO. 4

PLANT-TO-THE-ROW TESTS ON SEEDLINGS OF STRAWBERRY

By MARIANO E. GUTIERREZ

Of the Bureau of Plant Industry, Manila

FIVE PLATES

Strawberry improvement is comparatively a recent development of barely 50 years standing. The breeding of new varieties and the novelties offered to the trade, from time to time, were generally accomplished by hybridization. It should be borne in mind that this improvement by crossing was done in countries highly adapted to strawberry; only Canada accomplished certain improvement through seedling selection.(1)

At the Baguio Plant Industry Experiment Station, Baguio, Mountain Province, Philippines, where the most extensive culture of Philippine strawberry is located, the main problem seems to be adaptability, considering the fact that the climatic and soil conditions in Baguio are far remote from those obtaining in the well known strawberry regions of the world. Before any improvement by hybridization can be instituted, it is necessary that varieties be adapted first. Indicative of the hazards involved in strawberry culture is the fact that many of the varieties tried have lost some of their outstanding characters and qualities at home while some have acquired undesirable ones, such as, turning from sweet to sour berries or losing the runner production. Of 31 separate introductions from the United States and elsewhere, only about one-half dozen are doing fairly well.(2)

PREVIOUS WORK

It would be equally interesting and instructive to quote tinent parts of the initial work on strawberry seedlings here to be able to comprehend the real objective behind the pre work:

"Since all our fields of strawberry were the result of continu asexual propagation from plants highly adapted and bred fro the countries of origin, we have not made any change in their reaction to the environment. Since a plant is both a product of heredity and environment (3), it would seem that sexual propagation by the use of seeds will make a change in the resulting plants. We may grant that some of the seedling plants are first generation hybrids, due to occasional cross fertilization in the field and exhibit heterosis or hybrid vigor. For continuous asexual propagation of these hybrid seedlings, they will remain always first generation hybrids, exhibiting the desirable hybrid vigor, which will be for the better.

"It is believed that with sexual propagation, the new environment may have been impressed in the seeds, or the adaptability to the new set of conditions could be obtained more readily by the use of seedling material than the asexually propagated material for several years. The great variability exhibited by these seedlings, the recovery of certain characters or the obtaining of new ones—all prove that improvement in several characters may be obtained by the rigid selection of the best seedlings of these varieties.

"For improving our indifferent varieties, exhibiting poor or fair adaptability, this method of propagation opens untold possibilities."

THE ORIGIN OF THE VARIETIES USED

In order to determine the origin of the varieties studied and to have a basic understanding of their individual performances when subjected to the improvement by the use of seedlings, the only available data culled from an exhaustive work on strawberry improvement in the United States are quoted hereunder (1).

"*Wilson.*—Oldest cultivated variety, introduced 75 years ago; productive, firm-fruited, adapted to widely different conditions. One of the varieties responsible for the extension of strawberry culture.

"*Missionary.*—Found in the wild as chance seedling. May have originated from seed of cultivated varieties or as the res

of bees carrying pollen of cultivated sorts to the native strawberry.

"*Mastodon.*—Introduced in 1924. Kellog Prize × Superb. Productive, everbearing, and produces runners freely.

"*Bellmar.*—Introduced in 1931. Missionary × Howard 17. Attractive, good flavor, large.

"*Big Joe.*—No data. (Introduced in 1931 at Baguio from Allen Nurseries and Seed House Geneva, Ohio).

Fairfax.—Introduced in 1932. Unknown origin. Vigor, high flavor, disease resistant."

OBJECT

The object of these tests, being a continuation of our seedling selection as appearing in this Journal(2), is to isolate some adapted and desirable strains from the second selection of seedlings of P. I. 9,773–Wilson P. I. 14,256–Missionary, P. I. 12,251–Mastodon, P. I. 12,249–Bellmar, P. I. 10,746–Big Joe, and P. I. 12,247–Fairfax.

TIME AND PLACE

This covers the third year of the work, conducted during the strawberry season from August 1937, to May, 1938, at the Baguio Plant Industry Experiment Station, Baguio, Philippines.

MATERIALS AND METHODS

The few seedling strains, namely: 8 of Wilson, 9 Missionary, 8 Mastodon, 4 Bellmar, 2 Big Joe, and 3 Fairfax, being the only ones selected after the second season, were cultured separately in test rows.

It should be understood at the outset that it was impossible to obtain equal number of plants for each test row, because of the individualistic character of each seedling in its suckering ability and runner propensity.

On August 28, 1937, the selected seedlings were separately planted in rows 17 m. long, and 60 cm. between the rows, and the plants were set 30 cm. apart in the rows. The ridge, rather than the bed culture was used in order that the plants of the selections would be equally distanced and to insure more uniform conditions. Every third row was planted with the original stock of asexually propagated material of each variety to serve as check. Some strains occupied one full row, others a part of a row, and in one case one strain occupied two rows. All the rows were uniformly fertilized just before the blooming period

about the end of October, 1937, with Fertilica (10% N—10% P_2O_5–24% K_2O) at the rate of one ton per hectare.

While the strains consisted of varying number of representatives which was inevitable, the observations taken were based on the plant as the unit. These were related to their uniformity or non-uniformity as shown by all the sister plants of each strain, comparative vigor of the plants, time of bearing, size of berry, productiveness, and other distinguishing characters. These observations were convincing enough, as they showed distinctly individualistic characters. Likewise, the average yield per plant of each strain was taken as the unit of yield and the basis of comparison, instead of the whole production of each test row. Picking of the berries of each test row was done separately thrice a week. The harvested crops were brought to the laboratory and were separately weighed and recorded. For obvious reasons, the probable errors of the test rows were not calculated and only the arithmetical average is given for each strain. In the matter of yield, the strain tests of the best seedlings to be conducted in the following season would give more reliable yield results.

The results of the test rows, showing their condition with respect to the uniformity of the sister plants, the number of plants of each seedling strain, the total yield for five months and the average yield per plant are shown in the following table:

TABLE 1.—*Seedling strain numbers of the different varieties, the condition of the rows, number of plants per strain, total yield of the strains in kilos and the average yield per plant in kilos.*

	Wilson									
Seedling strain No.	Check	3	14	5	11	16	18	Check	19	22
Condition of test row	[1] fu	[2] nu	[3] u	u	nu	u	fu	fu	u	u
Number of plants	45	8	13	29	24	21	27	48	20	27
Total yield December 11, 1937 to May 4, 1938	4.23	0.28	3.67	7.11	2.54	3.59	4.18	6.49	6.29	6.92
Average yield per plant	0.094	0.035	0.282	0.245	0.106	0.171	0.155	0.135	0.314	0.256

	Missionary												
Seedling strain No.	Check	17/2	8	16	9	Check	[4] 13	Check	17	19	Check	23	V 7
Condition of test row	nu	fu	fu	fu	u	fu	u	fu	u	u	fu	u	nu
Number of plants	48	21	53	12	42	44	100	50	55	43	54	43	10
Total yield December 11, 1937 to May 4, 1938	9.35	4.65	9.46	3.34	14.96	9.40	44.40	10.16	14.65	13.65	9.96	10.95	0.73
Average yield per plant	0.195	.221	0.179	0.278	0.356	0.214	0.444	0.203	0.266	0.317	0.184	0.255	0.073

[1] fu = fairly uniform; [2] nu = non-uniform; [3] u = uniform; [4] occupied 2 rows.

TABLE 1.—*Seedling strain numbers of the different varieties, the condition of the rows, number of plants per strain, total yield of the strains in kilos and the average yield per plant in kilos.*—Continued.

	Mastodon									
Seedling strain No.	Check	2	4	6	8	13	14	Check	17	15
Condition of test row	nu	fu	u	u	u	fu	nu	nu	fu	fu
Number of plants	53	20	10	19	12	9	23	50	40	11
Total yield December 11, 1937 to May 14, 1938	4.22	2.30	1.52	5.47	2.39	1.36	1.87	4.04	5.98	1.50
Average yield per plant	0.080	0.115	0.152	0.288	0.199	0.51	0.081	0.081	0.149	0.136

	Belmar					Big Joe			Fairfax			
Seedling strain No.	Check	1	11	8	3	Check	8	10	Check	1	2	3
Condition of test row	fu	nu	u	nu	u	fu	u	u	nu	nu	nu	nu
Number of plants	60	24	22	7	53	23	12	9	28	9	4	9
Total yield December 11, 1937 to May 14, 1938	4.54	1.45	4.20	0.37	8.78	1.65	1.75	1.23	1.58	0.56	0.18	0.10
Average yield per plant	0.076	0.060	0.191	0.053	0.166	0.072	0.146	0.137	0.056	0.062	0.045	0.011

[1] fu = fairly uniform; [2] nu = non-uniform; [3] u = uniform; [4] occupied 2 rows.

OBSERVATIONS AND INTERPRETATIONS OF RESULTS

As there were six varieties studied alongside their respective selected seedling strains, the observations were made separately among the strains of each and, likewise, the comparison was made among them and their respective check rows.

Wilson seedling strains.—There were indications of some variability among the eight selected strains tested. One remarkable variation noted was the varying size of the leaves; some strains showed larger leaves than the others. In comparison with the check rows, the seedling strains did not show appreciable disparity. In the productivity and the size of berries, there were marked differences. Seedlings Nos. 3 and 11 gave much lower yields than the checks. On the other hand, Strains No. 5, 22, 14, and 19 in the ascending scale, gave superior average yields per plant over the check rows. As a rule, the strains showing uniform plants gave the highest yields, and this fact held true for all the high yielding strains of all the varieties.

Missionary seedling strains.—Among the varieties studied the Missionary seedling strains showed the widest variability in practically all characters and qualities (Plate I). None of the seedling strains showed much similarity with the asexually propagated material serving as checks. The latter were very much smaller in foliage spread and shorter. They produced their distinctive dark red colored, firm-fleshed, and sour berries. In foliage development, vigor, height, yield, shape, size of berries, the seedling strains showed marked superiority over the original imported Missionary variety (Plates 1 and 5). With only two exceptions, the average yields of the seedling strains were higher than those registered by the checks. Among the six varieties, Missionary showed the most promising strain, in productiveness with an average yield of 0.444 kg. per plant. Seedling No. 13 was not only the most productive among Missionary seedlings but also topped all other strains of all the varieties studied. (Plate 2.) This fact becomes all the more remarkable, because the average yield was secured from 100 plants, representing the largest number of sister plants for any strain tested (Plate 1). The berries though small were very abundant and sweet (Plate 5). May not these characteristics be those of the wild progenitor of which this variety is supposed to have partly come? Seedling No. 2 gave the largest-sized berries among all the varieties (Plate 3). Seedling No.

17 produced large characteristically shaped berries, elongate with large middle, and pale but sweet berries. Most of the berries fall under first class as to size. (Plates 4 and 5.) Seedling No. 19 produced irregularly shaped berries. Seedling No. 8 was a sweet early bearing strain but likewise stopped fruiting earlier than the other Missionary selections.

The runner propensity was noted to be a distinctly strain characteristic—found in some selections such as No. 13 while totally absent in others such as No. 8.

Most of the seedling strains produced sweet berries, a radical departure from the uniformly sour taste of the original Missionary constituting as it were, a significant advance in its amelioration.

Mastodon seedling strains.—Although the differences were not so marked as in the Missionary seedlings, Mastodon exhibited some variation in comparison with the checks. This should not be surprising as Mastodon is the result of a cross of two well known varieties. All the seedling strains outyielded the check rows. The greater adaptability to local conditions and the superior yield are the advanced steps in the improvement by the use of seedlings. Seedlings No. 13, 4, 8, and 6, in the ascending order, were decidedly superior to the other Mastodon strains and the checks.

Bellmar seedling strains.—Of the few seedling strains tested, Nos. 3 and 11 turned out to be productive and good strains.

Big Joe seedling strains.—The only two selected strains cultured were superior in yield to the check row.

Fairfax seedling strains.—No notable improvement was observed in the selected strains. This is a variety of high quality, but unfortunately unadaptable to our local conditions.

In order to increase rapidly the few promising strains of the different varieties, seeds of these were collected separately and were dried and later sufficient quantity of each was sown in seedflats and in the glasshouse. It is not intended to mix the plants of these F_1 seeds with original seedling strain selections, as it is not known if they will turn out the same plants. For one thing the seeds were collected from plants that were not selfed.

SUMMARY

The results of the second-year selection of seedling strains of Wilson, Missionary, Mastodon, Bellmar, Big Joe, and Fairfax are given.

Under Baguio conditions, adaptation and improvement of strawberry varieties can be accomplished by the use of seedling selections, i. e., sexual propagation as opposed to asexual.

After the adaptation work and selection of desirable strains, hybridization, as another method of improvement, should be the next logical step.

As a rule, uniformity of the sister plants of each strain was a condition conducive to high yield.

The following seedling strains are promising:

Wilson Nos. 5, 22, 14, and 19.
Missionary Nos. 17, 19, 9, and 13.
Mastodon Nos. 13, 4, 8, and 6.
Bellmar Nos. 3 and 11.
Big Joe Nos. 10 and 8.
Fairfax No. 1.

The above-mentioned strains need to be tested in bigger plots for more reliable comparison of yields and desirable characters and qualities.

The plants of the F_1 seeds should not be mixed with the corresponding seedling strains propagated asexually in the test rows, unless they prove to be the same in all particulars and give the same performance.

A limited distribution of the F_1 seeds, however, to propitious regions and to lower altitudes should be made in order to study their behavior, especially in the latter region. For this purpose, some seeds of Missionary selections were sent for trial to Lipa Coffee-Citrus Station, Batangas, the College of Agriculture, and Bukidnon.

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ILLUSTRATIONS

PLATE 1

Test rows of Missionary seedling strains with the check rows. Note the vigorous development and vegetative luxuriance of the seedling strains in comparison with the check rows.

PLATE 2

A plant of Missionary seedling No. 13 with the leaves pushed aside to show its prolificacy. Note the abundance of small berries.

PLATE 3

A plant of Missionary seedling strain No. 2 with the leaves pushed aside to show its large berries.

PLATE 4

A plant of Missionary seedling No. 17 showing its large characteristically shaped berries. Note the enlarged middle of the berries.

PLATE 5

A graphic comparison of 7 berries each of four Missionary seedling strains and of the check. Note the varying sizes, shapes, and color; largest size of No. 2 and similarity of color with the check; the characteristic shape, large size, and paleness of No. 17; the irregular shape of No. 9; and the small sized berries of No. 13, smaller even than those of the check.

PLATE 1

PLATE 2

PLATE 3

PLATE 4

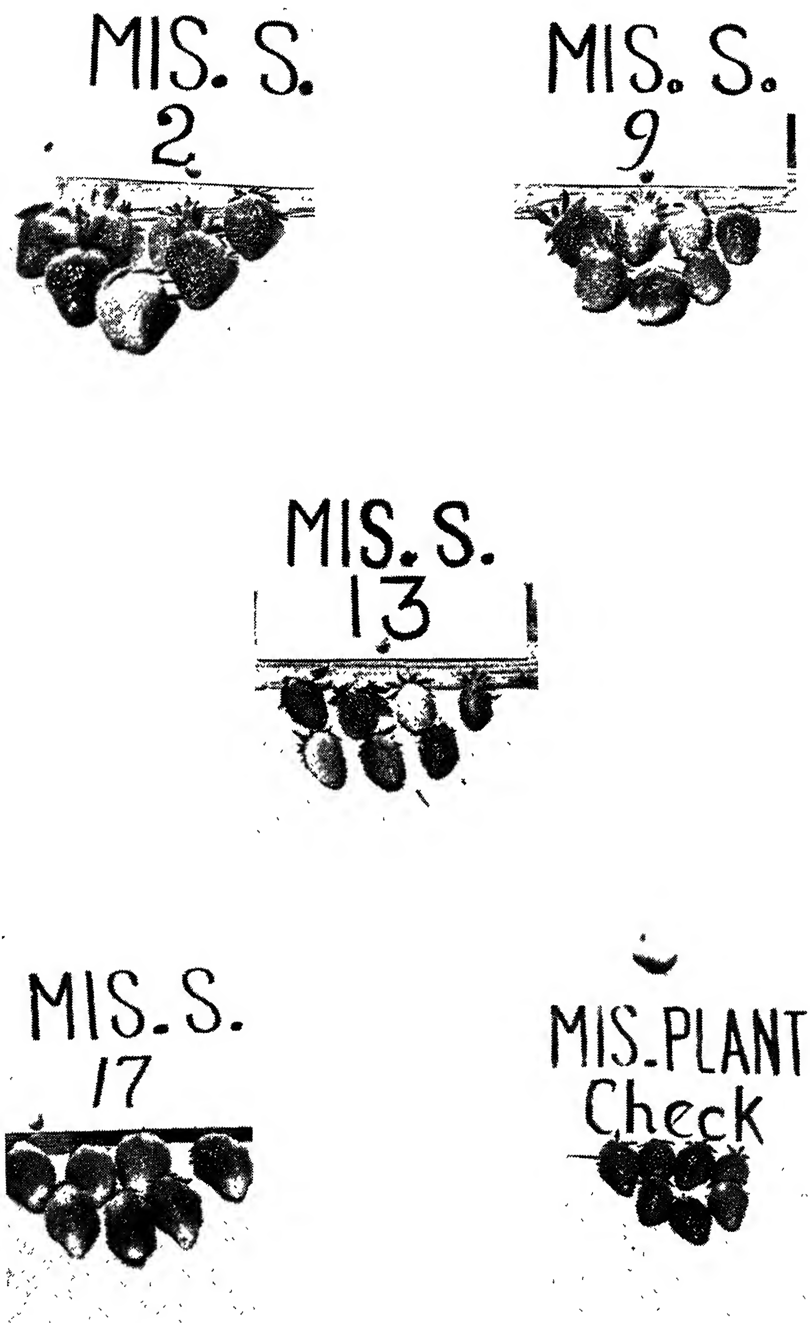

PLATE 5

VIABILITY OF SEEDS OF COTTON AS AFFECTED BY MOISTURE AND AGE UNDER DIFFERENT METHODS OF STORING *

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The preservation of the viability of cotton seeds for the next planting season has always been the concern of cotton planters. The planting of viable seeds helps to minimize, to a certain extent, the time, energy and money spent in the raising of a crop. The farmer is also assured of a fair margin of profit by curtailing the increment cost of various farm operations which might have been put to a better purpose. Thus, seed dealers throughout the country in order to rightfully maintain their prestige as seed distributors must have a good supply of seeds with a high percentage of germination. In case of an over supply, however, the seeds should be properly stored in order to preserve their viability until next season.

Due to the persistent complaints of planters who bought cotton seeds from this Bureau and also of our fieldmen that the seeds they secured were of poor viability the writer has undertaken this study under the direction of Dr. Vicente C. Aldaba, former Chief, Fiber Research Section. This study, therefore, was conducted with the end in view of finding an effective, economical, and practical way of storing cotton seeds under local conditions which might eventually supplant the crude way commonly practised by our farmers. Should the proposed plan for a government owned cotton seed farm materialize with the object of producing one single high-grade uniform variety of cotton crop throughout the Philippines, the results of this study shall eventually prove useful.

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* This study has been undertaken under the direction of Dr. Vicente C. Aldaba, former Chief, Fiber Research Section, Bureau of Plant Industry, Manila. The writer wishes to acknowledge the valuable services of Messrs. Eladio Sablan and Pedro A. Rodrigo, Assistant Agronomists, Bureau of Plant Industry, Manila, for their advice and coöperation in the preparation of this paper.

This study was carried out in the Fiber Research Section, Bureau of Plant Industry, Manila. The seeds were prepared for storage on May 26, 1936 to June 6, 1936. The study ended on June 18, 1937.

REVIEW OF LITERATURE

The cottonseeds, as far as the writer could ascertain, has never been a subject of seed storage experiment in the Philippines.

Wester (1924) states that in the Temperate Zones practically all seeds may be dried and still retain their viability, whereas in the Tropics the seeds of many important plant species, such as tea, coffee, cacao, mango and mangosteen lose their germinative power if they are allowed to dry out. According to Vibar and Rodrigo (1929) the viability of seeds decreases rapidly in the Philippines because of high humidity-temperature conditions prevailing throughout the year. They reported that farm crop seeds like rice, corn, mongo, cowpea, tapilan, soybean, etc. were able to maintain their viability very much longer when stored in air-tight container than when kept in cloth bag. Coronas (1920) gave as the average annual rainfall of the Islands about 2,366 millimeters; the relative humidity, 80 per cent; and the temperature, 26.9° C. Morada (1924) in an experiment on the effect of sun-light on the germination of papaya seeds showed that seeds under total shade during the whole day did not germinate but on exposure to sunlight for one-half day, they germinated. Brand and Sherman (1913) stated that mature seed-cotton could be stored with perfect safety if care was taken to have the seeds free from atmospheric moisture when stored. They further stated that the practical point to be observed was that cotton from which planting seed is to be saved must be thoroughly dried before bulking or must be spread out in thin layers as to prevent any noticeable development of heat if the germination of the seeds is not to be affected.

The use of concentrated sulphuric acid (commercial) for delinting cottonseed at short duration has no effect on the germinative power of cottonseeds as found out in another experiment conducted by the writer. Another worker has shown that sulphuric acid treatment has an stimulating effect on the germination of cotton seeds when soaked for 20 minutes.

Simpson (1935) in an experiment conducted at James Island, near Charleston, S. C., found that freshly opened cotton bolls

contain a considerable percentage of dormant seeds. However, this dormancy, according to him, may be eliminated by drying and storing the seeds for a short period.

In studying the moisture content and germination of cotton seeds during the period of boll opening at the United States acclimatization field station near Charleston, S. C., Simpson (1935) found that germination tests made on the seeds immediately after they were harvested were unreliable. He further stated that fresh seeds germinated very slowly, and many seeds though apparently sound, failed to germinate in the germination chambers even after 24 days. However, when fresh seeds were thoroughly air-dried and stored for a few weeks, better germination was obtained.

Simpson and Stone (1935) found that seeds from bolls just opening, when dried and stored for a short time, gave higher percentage of germination than the seeds which have been exposed for a longer period in the field. They further stated that seeds from bolls harvested when they were just opening during a period of dry weather gave higher percentage of germination than the seeds from bolls harvested when they were just opening during a rainy weather.

Simpson (1935) showed that storage experiments with Sea-island and upland cotton seeds under the humid condition prevailing at James Island, South Carolina, showed that in ordinary storage, cotton seed deteriorates rapidly after 2 years. A definite relation is indicated between the moisture content of the seeds during storage and the rapidity of deterioration. Sea-island cotton seeds, with a moisture content reduced below 8 per cent, when stored in tin container to prevent the rapid re-absorption of moisture, retained their germinative power with only slight impairment for 4½ years. Upland cotton seed stored under various conditions and containing from 8.75 to 13.78 per cent moisture deteriorated rapidly when the moisture in the stored seeds remained about 10 per cent. Dried seeds stored to prevent re-absorption of moisture showed only slight deterioration after 2½ years. Seeds which contained 13.78 per cent moisture and stored to prevent drying lost completely their viability in 9 months.

MATERIALS AND METHODS

Definition of terms used.—"Delinted cottonseed" is the term used here to mean cottonseed stripped of its lint by means of concentrated sulphuric acid for three minutes duration, washed

with tap water to remove the excess acid and later dried. "Cottonseed" is the seed after the cotton fibers or lint are removed by the process known as ginning. Whereas, "seed-cotton" is the term applied to seeds still bearing the cotton fiber picked from ripe bolls.

Five sacks of one-month-old (from date of harvest) "Kapas Purao" seed-cotton, weighing 30 kilos each were used in these tests. Using one-month-old seed samples for the germination tests would eliminate dormancy as a factor. The material used was harvested in the crop season of 1936 from Oriental Misamis, Mindanao.

The bulk of the seed-cotton was mixed thoroughly, stored and selected, discarding the stained cotton, so that only sound seed was used. They were equally divided into three samples. One-third which was used for samples 3 and 6, remained as seed-cotton; the second third was ginned in an Eagle No. 10 cotton gin and was hereafter termed as "ginned cotton", or "Cotton-seed" and was labeled samples 2 and 5; the remaining one-third was also ginned and delinted with sulphuric acid (commercial) for 3 minutes duration and was hereafter called as "delinted cotton-seeds" and was labeled as samples 1 and 4.

The delinted cottonseeds were immediately washed several times with tap water to insure the thorough removal of the excess acid. Sulphuric acid (commercial) was used as an effective means of removing the linters without hampering the germinative power of the seeds. The seed once removed of its linters appeared as bare seed similar to kapok seed. The bare delinted seeds were then spread in thin layers to dry under shade.

Samples 1 and 4, 2 and 5, and 3 and 6 were each further divided into two equal parts representing the sun-dried and air-dried samples. One-half of each was spread in abacá burlap in thin layers to dry under shade. The other halves were exposed to the sun for approximately 7 hours each day. The process was continued for five consecutive days, thereafter.

To prevent as much as possible the re-absorption of moisture from the air, especially in the case of the sun-dried samples, approximately, 30–40 and 50 grams portions of samples 1, 2 and 3, were all separately kept in cellophane envelopes. Thorough mixing of each sample was necessary to insure a composite sample. Composite samples in cellophane envelopes were immediately and correspondingly stored in properly labeled tin cans

with tight fitting lid. The cover was later zealed with melted paraffin. In a practical way, petroleum or gasoline cans could serve the purpose effectively having the advantage of easy shipment to interested parties without affecting the viability of the seeds. The air-dried samples were separately stored in made-to-order abacá sacks.

Initial moisture and germination tests were made on each sample, both for the sun-dried and air-dried, on May 24, 1936. Subsequent moisture and germination tests were made from the same samples after 6 months of storage and approximately 3 months interval, thereafter.

RESULTS

This paper presents a summary of the results of one year study in Table 1 which gives the average moisture contents and the average percentage of germination of the different kinds of cotton-seeds (variety Kapas Purao) under different methods of storing.

AIR-TIGHT CONTAINER VERSUS BURLAP SACK

The results of this experiment show that under conditions prevailing at the Central Experiment Station, Bureau of Plant Industry, Manila, sun-dried seeds stored in air-tight containers retained their viability which made them still suitable for planting purposes after one year in storage. The air-dried seeds stored in burlap sacks on the other hand, had very low percentage of germination and thus could not be of good use for planting purposes. According to Simpson (1935), the type of storage did not materially affect the keeping qualities of the seeds except as it prevented the reabsorption of moisture. He further stated that there was no appreciable difference between the germination percentages of air-dried seeds stored in sealed can and air-dried seeds stored in a burlap bag. This is contrary to the findings reported in this paper.

1. *Moisture content of seed.*—The data in Table 1, show that for the sun-dried seeds stored in air-tight containers, there was a gradual rise, although slight, in the moisture content during the period of storage. The probable explanation for this, is that the samples though stored in air-tight containers re-absorbed moisture to a certain degree not from the atmosphere but from the moisture liberated from the paste used in sealing the cellophane envelopes. For a period of approximately one year, the moisture content of the sun-dried seeds stored in air-tight containers

TABLE 1.—*Viability of the seeds of cotton as affected by moisture and age under different methods of storing at the Bureau of Plant Industry, Manila.*[1]

Date	Sundried (Stored in air-tight containers)						Airdried (Stored in bu lap sacks)					
	Sample 1 (Cottonseed, delinted)		Sample 2 (Cottonseed)		Sample 3 (Seed-cotton)		Sample 4 (Cottonseed, delinted)		Sample 5 (Cottonseed)		Sample 6 (Seed-cotton)	
	Average moisture	Average germination	Average moisture	Average germination	Average moisture	Average germination	Average moisture	Average germination	Average moisture	Average germination	Average moisture	Average germination
	per cent	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*
May 24, 1936 (initial)	5.47	89.50	5.11	92.30	4.29	94.40	8.57	90.10	8.13	91.80	7.89	93.30
December 1, 1936 (6 months)	7.24	59.00	6.87	68.04	4.91	91.96	12.08	27.00	10.32	38.30	11.74	19.70
March 18, 1937 (9 months)	8.01	63.18	8.10	72.40	7.50	90.07	11.70	11.30	10.65	14.70	10.62	16.60
June 18, 1937 (1 year)	9.66	48.88	8.86	63.10	8.33	80.58	13.46	1.33	12.63	2.66	10.91	14.00

[1] Data on germination are reported as averages of five trials in triplicate, and moisture percentages as averages of five trials in duplicate.

ranged from 5.47 to 9.66 per cent for cottonseed (delinted), 5.11 to 8.86 per cent for cotton-seeds, and 4.29 to 8.33 per cent for seed-cotton.

2. *Relation of moisture to germination.*—The importance of moisture to seed deterioration is well illustrated in figure 1. A

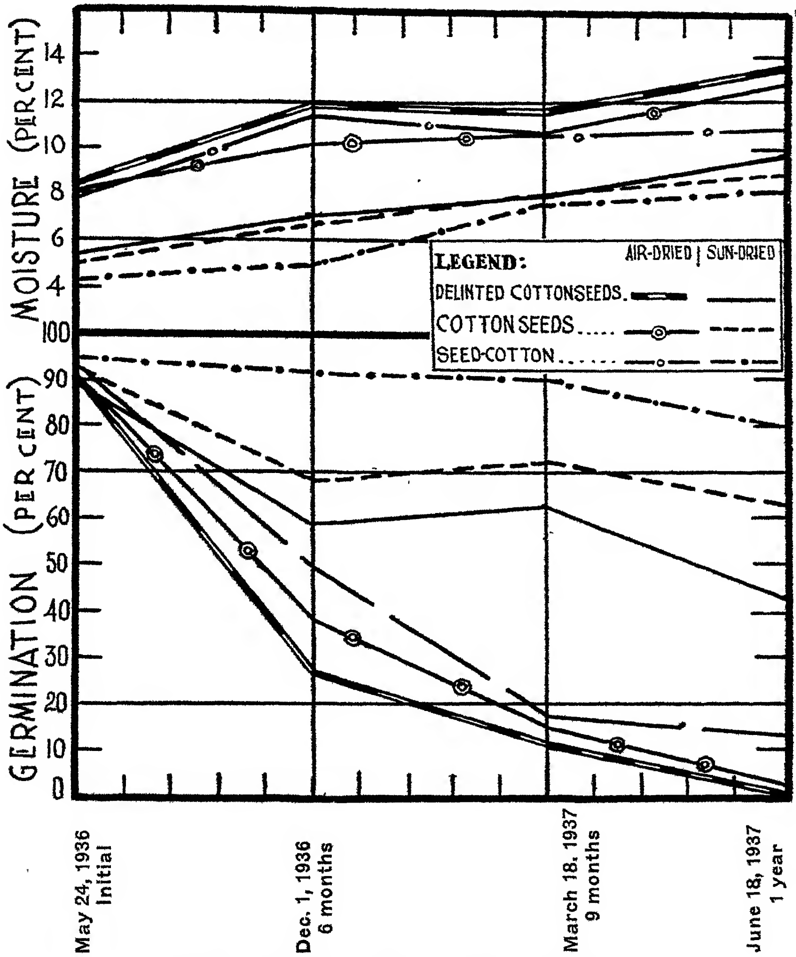

FIGURE 1. Relation of moisture content to germination.

definite relation is indicated between the moisture content of the seeds during storage and the rapidity of deterioration. Figure 1 shows that a rise in the moisture curve is followed by a fall in the germination curve. It will be noted also that seeds stored in air-tight containers, having re-absorbed moisture below 9 per cent, materially lengthen the time that they could be safely

stored. This corroborates the findings of Rodrigo (1935) on some farm crop seeds when he found that the percentages of germination of rice, corn and some beans were maintained over 70 per cent after storing in sealed container from 57 months (4 years, 9 months) to 132 months (11 years).

No very positive sign of deterioration in viability were noted after 6 months of storage in the case of seed-cotton stored in air-tight containers. However, seeds stored in burlap sacks and subjected to fluctuation in atmospheric humidity deteriorated rapidly at the end of 6 months in storage especially when the moisture content in the stored seeds continually increased above 10 per cent. Simpson (1935) has proven also that a moisture content in excess of 10 per cent is a critical factor in the longevity of stored cotton-seeds. Delinted cotton-seeds stored in burlap sacks for one year increased their moisture content from 8.57 to 13.46 per cent, and this gave 1.33 per cent germination only. It indicates that a moisture content of 13 per cent is detrimental to the viability of stored delinted seeds.

RELATION OF VIABILITY TO KIND OF SEED

A comparison of the results obtained with sun-dried seeds stored in air-tight containers in Samples 1, 2 and 3 shows appreciable and marked differences in germination percentages throughout the tests. As will be noted in Table 1, sample 1 (delinted) gave lower per cent germination than sample 2 (cotton-seed). Sample 3 (seed-cotton) has maintained the highest germination throughout the tests.

The decrease in viability became evident in sample 1 (delinted seed) during the period from May 24, 1936 to June 18, 1937, the germination percentage as of June 18, being 45.62 per cent less than the initial germination. The initial germination of sample 2 (cotton-seed) when placed in storage on May 24, 1936, was 92.30 per cent but dropped to 63.1 per cent on June 18, 1937, or 29.2 per cent less than the initial germination. A very significant result was obtained in the case of sample 3 (seed-cotton) which was stored in air-tight containers. The viability of the seeds was retained with very slight impairment up to June 18, 1937. At the beginning of the test, the germination was 94.40 per cent. Over a period of approximately 9 months after storage, the same sample gave 90.07 per cent germination, being only 4.33 per cent less than the initial germination. However, the same seed-cotton on June 18, 1937 gave a germination of

80.58 per cent with a moisture content of 8.33 per cent at the conclusion of the tests.

Air-dried seeds which were stored in burlap sacks gave, at the beginning of the tests, the following percentages of germination: Sample 4, (delinted-seed) 90.1 per cent; sample 5, (ginned seed) 91.8 per cent; and sample 6, (seed-cotton) 93.3 per cent. After 6 months of storage, these same samples, with the exception of the seed-cotton, in practically all tests, showed pronounced decrease in germination that they were practically useless for planting purposes. (Table 1.) These decline at an increasingly rapid rate continued after 9 months up to one year of storage. The latest determination made as of June 18, 1937 gave the percentages of germination as follows: Sample 4 (delinted seed) 1.33 per cent; sample 5, (ginned seed) 2.66 and sample 6, (seed-cotton) 14.0 per cent; being 88.77, 99.14 and 79.3 per cent, respectively, less than the initial germination as of May 24, 1936.

The results of the foregoing experiment show that the seed-cotton recorded the highest percentage of germination while the delinted cotton-seed recorded the lowest. These were noted both in air-tight containers and in burlap sacks. It is very evident that the linters of cotton-seed and the lint of seed-cotton are important factors in preserving the viability of the seeds and in preventing the re-absorption of moisture by the seed proper.

SUMMARY

The storage experiment with cotton-seed of "Kapas Purao" variety under conditions prevailing at the Central Experiment Station, Bureau of Plant Industry, Manila, showed that sun-dried seeds stored in air-tight containers whether delinted, ginned, or seed-cotton, retained sufficiently good viability for planting purposes after one year in storage; while the same kind of seeds kept in burlap sacks were useless for planting purposes after six months in storage.

Sun-dried and air-dried seed-cotton maintained higher percentage of viability than either ginned or delinted cotton-seeds in practically all the tests, as the storage period was prolonged.

A definite relation was indicated between the moisture content of the seeds during storage and the rapidity of deterioration. Maintaining the moisture content of the cotton-seed during storage below 9 per cent as in air-tight containers materially

lengthened the time that the seeds could be safely stored. Seeds subjected to fluctuations in atmospheric humidity as those stored in abacá burlap deteriorated rapidly especially when the moisture content in the seeds continually increased above 10 per cent. Air-dried delinted cotton-seed containing 13.46 per cent moisture gave only 1.33 per cent germination after one year in storage.

RECOMMENDATIONS

It is recommended that cotton-seeds for planting purposes should be kept in air-tight containers in order to maintain a good supply of viable seeds.

More detailed study on storage of seed-cotton to solve the problem of bulkiness of the stored material should be undertaken.

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NOTES ON THE PROPAGATION OF THE PONDEROSA CHICO

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FIVE PLATES

The Ponderosa chico, *Achras zapota* Linn. var. *Ponderosa*, in the Philippines originated from seeds introduced into the Islands in 1912 from the botanical garden at Buitenzorg, Java. The oldest tree which was planted in the yard of Mr. Silvio Lopez of Los Baños, Laguna, first fruited in 1927 or around 15 years after planting. This tree may be considered as the original parent stock of the few Ponderosa chico trees now distributed in the Islands.

The average-sized fruit of the tree is exceptionally big and of good quality (Plate 1, fig. 2). Thus, when Gonzales[1] described it in 1932, he called it "an improved seedling variety of chico." An averaged-sized fruit of this tree is easily four to five times larger or heavier than an average-sized native chico fruit. The tree, however, seems to have one defect in that it is rather a shy bearer. Nevertheless, despite this defect, persons who have seen and tasted its fruits are practically unanimous in their desire to include this chico variety in their backyard orchard. Of course, because of the great demand for planting materials, the tree has always been heavily marcotted on and, therefore, has never been given an opportunity to show its normal ability to bear fruits. The great interest of people who have seen or known this chico together with the fact that the supply of planting materials was then limited prompted the writer to try different methods of propagating it.

The data presented in this paper include observations made from December, 1928 to August, 1938, a period of almost 10 years. Some of the observations were made in Batac, Ilocos Norte, where two seedling trees were planted and in Los Baños, Laguna. Most of the data here presented, however, were obtained in the backyard orchard of the writer in San Juan Heights, Rizal Province.

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[1] Gonzales, L. G. An improved variety of chico (*Achras zapota* Linn. var. Ponderosa. Phil. Agr. 20: 604–605. 1932.

METHODS OF PROPAGATION EMPLOYED

Marcotting.—This is the oldest and until recently, the only method of propagating the native chico. Naturally, this method was employed in securing planting materials from the original tree of Mr. Lopez. The writer was fortunate, after several attempts, to have been able to secure three marcotted branches at a time. These branches were marcotted in October, 1932 and were severed from the parent tree in September, 1933 or about 11 months thereafter. These were planted on January 1, 1934 (Plate 1, fig. 1).

Of the 10 marcotted branches from three- to four-year old marcotted trees in San Juan Heights, Rizal, six succeeded in producing roots while four died, representing 60 per cent success. The period from marcotting to cutting varied from 6 to 14 months. It may be mentioned that the marcotting was always done in May and June, or in other words, at the commencement of the rainy season. It may also be pertinent to state that the soil used in marcotting had a great deal to do in the rapidity of the branch to root. Where a mixture of 50 per cent loam and 50 per cent fine sand was used, the roots were seen to strike out the ball of earth in 4½ to 5 months after marcotting, whereas it took from 7 to 12½ months for the roots to strike out where loam and clay soils were used.

In cases where valuable and rare varieties are propagated like the Ponderosa chico, marcotting is a very extravagant and slow method of propagation. It is also highly devitalizing to the tree especially when it is still comparatively young.

GRAFTING AND MARCOTTING

Raising seedling for stock.—Due to lack of some definite information as to the most suitable stock for Ponderosa chico, three varieties were tried, namely, St. Croix, Native and Ponderosa. The seeds of St. Croix and Ponderosa germinated in from 16 to 32 days while the Native chico seeds germinated in from 25 to 44 days. The St. Croix and Ponderosa seedlings were found to be fast growers and under good nursery conditions, they were ready for inarching in 11 to 15 months after sowing the seeds (Plate 2, figs. 1 and 4); in 20 to 24 months they attained the size suitable for grafting. The Native chico seedling, on the other hand, was not ready for inarching until it was 30 to 36 months old (Plate 2, fig. 3).

In this connection, it may be of interest to present here the girth growth of 6 grafted Ponderosa chico trees ranging in age from 2 to 3 years with St. Croix chico as stock, and of 4 three-year old inarched with Ponderosa chico as stock. In the former where St. Croix chico was used as stock, the average diameter of the stock and scion taken about one inch (2.5 cm.) from the point of union were 2.3 and 2.1 centimeters, respectively. The average diameters of the stock and scion in the latter case (with Ponderosa stock) were 4.5 and 4.2 centimeters, respectively. While it may be rather premature to draw any definite conclusion now, at least, present indications show the great possibility of the Ponderosa and St. Croix chico seedlings as stock for the former.

Grafting.—The writer's first attempts to graft (cleft) the Ponderosa chico gave very low percentage of success. Due to the limited supply of stock and scion, and to the fact that the object was to obtain the highest percentage of propagated Ponderosa chico, because the work was done under private expense, this method was given up and inarching was resorted to. This, however, does not mean that the Ponderosa chico could not be propagated successfully by grafting. Perhaps, one who has acquired dexterity in the art of grafting would prefer this method to inarching especially when the source of the scion has its branches high from the ground. Trials made by skilled propagators at the Bureau of Plant Industry gave about 90 per cent success. Grafted Ponderosa chico trees planted at the Central Experiment Station, Manila, have been growing vigorously (Plate 3).

Inarching.—For beginners, inarching is the fastest and the surest way to propagate the Ponderosa chico. The whole operation is simple that it is not uncommon for a beginner to obtain 100 per cent success. With tall trees, however, the operation is rather laborious because of the fact that the potted seedling which is being used as stock has to be carried up in the tree or be provided with a support or platform. In the case of the Ponderosa chico where both the stock and scion are rare and the resulting inarched plant is very costly, the use of inarching even in its most laborious way is still justified.

Seedlings having a diameter of one-half centimeter or more at a point 10 centimeters from the base are ready for inarching. With a sharp knife, a tangential cut about five centimeters in

length is made on one side of the stem of the stock about 10 to 15 centimeters from its base. The cut should be clean and deep enough to include a part of the wood. A similar tangential cut should be made on the branch or twig (scion) to be inarched. The stock and scion are then put together on their "cuts" fitting them snugly so that their cut barks coincide with each other. Then they are tied together with budding tape (Plate 4, fig. 1).

The rapidity of the union between the stock and scion depends upon the nature of their growth. Rapid growing stock and scion, as is the case at the beginning of the rainy season effect more rapid union. A more or less perfect union was observed to have been effected in 35 to 60 days. Before the branch is cut, its base (below the point of contact) should be gradually cut. The object is to force the inarched branch to draw its water supply from the stock. It was also found advantageous to cut the top of the stock right above the point of union about a week or so before completely severing the inarched branch (Plate 4, fig. 1). The cut should be clean and as close to the point of union as could possibly be made. For obvious reasons, painting the cuts with white lead or with any ordinary paint is essential. If the union has been complete, the base of the scion just below the point of contact could be cut clean and painted, otherwise this may be delayed for a week or so. As a precautionary measure, the newly severed inarched plant should be put in a shade for about a week, after which it should be gradually put in the open.

Seed.—The fact that the original Ponderosa chico in the Philippines originated from seed gave the writer the idea to plant the seeds of two fruits obtained from it. The seeds (nine in number) were sown in December, 1928. Eight seeds germinated and three of the seedlings were transplanted in Batac, Ilocos Norte in April, 1930, and the rest were left at the Baguio Plant Industry Experiment Station. Of the three that were planted, one died and the other two grew into big trees. These trees had a very vigorous growth. One of the trees was cut accidentally at the base while young and this caused the tree to produce low and spreading branches (Plate 5, fig. 1). Both trees began to bear flowers in May, 1936, but the first fruits were noticed only with the October, 1936, flowering.

BEARING AGE

Marcotted tree.—The seven marcotted trees that were observed at San Juan Heights, Rizal, began to flower with the

first flush after setting them in their permanent places. One fruited after one year, four after two years and two after three years. Compared with native marcotted chico, the Ponderosa grew comparatively fast. The vigorous growth of the tree may have caused the delay in fruiting, or it may be an inherent character of the tree.

Grafted tree.—Grafted trees at the Central Experiment Station began to bear flowers about 1½ years after planting. None of the trees (Plate 3, fig. 2) have so far set in fruits three years after planting.

Inarched tree.—Inarched trees were observed to begin flowering two years after planting. None of the four three-year old inarched trees, however, have so far set in fruits (Plate 2, fig. 2).

Seedling tree.—Two seedling trees planted by the writer began to bear fruits in 7½ to 8 years after planting or 8½ to 9 years after sowing the seeds. At this age the trees have attained a height of from 7 to 8 meters with a spread of 6.5 to 7 meters.

At this writing, the trees are in their second year of fruiting. Like the mother plant, they are also shy bearer, but unlike the mother tree, their fruits are much smaller; the fruits are a little bit bigger than the large-sized native chico. The superior quality of the Ponderosa chico (sweet, juicy and comparatively free from grit), however, has been maintained. Of the 50 fruits examined, 41 were single-seeded and the rest 2 seeded; none was found to have produced three seeds. Based from the performance of the two seedling trees mentioned above, it appears evident that the Ponderosa chico does not breed true to type in so far as the size of the fruit is concerned. To maintain the size of the fruit, the Ponderosa chico should be propagated asexually, either by marcotting, inarching or by grafting.

SUMMARY

The present paper includes some notes on the propagation of the Ponderosa chico covering observations for a period of 10 years.

Four methods of propagation have been tried; namely, marcotting, grafting, inarching and by seed. The Ponderosa chico has been found to respond to all these methods. Until recently, marcotting has almost exclusively been the only method of propagating the native chico.

Marcotting is an extravagant as well as a slow method of propagating the Ponderosa chico. The percentage of success was 60 per cent and it took from 6 to 14 months before the

marcotted branch was ready to be cut. A medium consisting of 50 per cent sand and 50 per cent clay loam was better than pure loam or clay soil for marcotting the Ponderosa chico.

With expert operators, grafting gives from 80 to 90 per cent success. Inarching is a surer method of propagating the Ponderosa chico, the percentage of success ranging from 95 to 100 per cent. This method is the most dependable for beginners.

Three kinds of chico were tried as stock for the Ponderosa chico, namely, Ponderosa, St. Croix, and the Native. The first two (Ponderosa and St. Croix) were found to be fast growers and are considered good stocks for Ponderosa.

Marcotted Ponderosa chico began to bear flowers with the first flush after planting, but did not bear fruits until the lapse of one to three years after planting. Grafted and inarched trees began to flower in one to two years after setting them in the field, but so far, none has been observed to set in fruits three years after planting.

Two Ponderosa seedling trees planted in Batac, Ilocos Norte, began to bear fruits in 7½ to 8 years after planting. These trees are vigorous growers; at this age they have attained a height of from 7 to 8 meters with a crown spread of 6.5 to 7 meters. The fruits of these two seedling trees were much smaller in size than those of the mother tree although the eating quality was similar.

ILLUSTRATIONS

PLATE 1

FIG. 1. A four-year old marcotted *Ponderosa* chico.

2. An average-sized mature fruit of the tree, $\times \frac{3}{4}$.

PLATE 2

Seedlings of different chicos. *Fig. 1*, One-year old *Ponderosa; 2*, inarched *Ponderosa* just severed from the parent plant (note the close and clean cut of the top end of the stock and the untrimmed base of the scion); *3*, a three-year-old native chico seedling; *4*, a 15-month-old St. Croix seedling.

PLATE 3

Ponderosa chico. *Fig. 1*, A row of two- to three-year-old grafted trees on St. Croix; *2*, a close-up view of one of the trees.

PLATE 4

FIG. 1. Inarched *Ponderosa* branches, almost ready to be severed from the parent tree. (Note the tops of the stock have already been cut close to the point of union.)

2. A three-year old inarched *Ponderosa* with *Ponderosa* stock.

PLATE 5

FIGS. 1 & 2. Eight-year old seedling trees from the original *Ponderosa chico* of Mr. Silvio Lopez, Los Baños, Laguna. (Note the vigorous appearance of the trees.)

1

2

PLATE 1

1 2 3 4

PLATE 2

1

2

PLATE 3

1

2

PLATE 4

2

1

PLATE 5

A PRELIMINARY SURVEY OF THE WATERMELON INDUSTRY IN BULACAN AND PAMPANGA [1]

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FIVE PLATES

The growing of watermelon, *Citrullus vulgaria* Schr., locally known as Pakuan or Sandia is still a minor industry in the Islands. The watermelon marketed in Manila comes almost exclusively from Bulacan and Pampanga. In certain sections of these provinces, however, the raising of watermelon has become a great source of income of the people.

Because of its growing economic importance and the manifest interest of prospective growers and because of the increasing demand for information about watermelon growing, the writer was assigned to undertake an investigation of the watermelon industry in Candaba, Pampanga and in Bocaue, Sta. Maria, Norzagaray, Angat, Bustos and Baliwag, Bulacan. The investigation was conducted during the watermelon season of 1937–1938.

The investigation had for its object the gathering of data relative (1) to the scope of the industry, (2) the area of land actually devoted to watermelon, (3) production, (4) the varieties planted, (5) the capital invested and the labor involved in the industry, (6) the approximate number of people dependent upon it, (7) the cultural methods that are in vogue and (8) the difficulties of the growers, with the aim in view of introducing some improvements in the present cultural practices that are being employed.

HISTORY OF THE WATERMELON INDUSTRY

In the absence of printed literature covering the development of the watermelon industry, the writer resorted to gathering information from old farmers in the center of watermelon production with respect to the history of the development of the industry. The farmers interviewed were unanimous in the claim that the growing of watermelon dates as far back as the

[1] Prepared under the supervision of Mr. F. G. Galang, Chief, Horticulture Section and Mr. Pedro A. Rodrigo, Assistant Agronomist.

beginning of the last century of Spanish dominion in the Islands. The farmers in the town of Candaba, Pampanga and of those in Sta. Maria and Bustos, Bulacan claim that they first grew the so-called Meck watermelon, a naturalized variety, the origin of which is not definitely known. Later the Valencia variety was introduced by the Spaniards from Spain and these two varieties were the varieties leading in hectarage. Only limited areas of land were being cultivated then and these were confined mostly to a small portion of the Candaba swamp and along the bank of the Angat River in Bulacan.

Gradually, the cultivation of watermelon has advanced. In some towns of Pampanga as Guagua, Sta. Rita, Bacolor, Apalit, San Simon, San Luis, Arayat with Candaba in the lead, is now quite extensive. Also, in the towns of Bocaue, Sta. Maria, San Jose, Norzagaray, Angat, Bustos, San Rafael, Baliwag and Plaridel, Bulacan, watermelon is becoming a major crop.

At the present time, the watermelon area covers practically all the Candaba swamp which is dried from November to June, and some of the lands bordering it with an approximate total area of about 4,207 hectares, and along the banks of the Angat River from San Jose to Bintug, Bulacan, with an approximate area of about 1,500 hectares. Other provinces such as Nueva Ecija, Rizal, Cavite, Tarlac, and Laguna are also producing watermelon in a limited extent.

VARIETIES PLANTED

Elayda(1) in his investigation in 1929, reported three varieties of watermelon that were being planted, namely, Meck, Valencia and De Jaspe. The last variety was the most important. In the investigation reported herein, however, other varieties were found being planted. The most important among the new varieties were Magliston or De Liston, Ramie, Santa Rosa White and Kinaramelo. De Liston and Ramie have gained popularity very rapidly among growers because of their size and distinct superiority in eating quality. The writer also found three minor varieties which were unnamed, and for convenience are designated in this report as Varieties A, B and C.

DESCRIPTION OF COMMERCIAL VARIETIES

Meck.—A naturalized variety, large and elongated, tapering gradually at the peduncle end. Rind, dark-green 1 to 1.3 cm. thick, light green ribbing and netting. Texture, fine grained, juicy, without aroma and flavor, not so sweet but good when

properly ripened. Flesh, tough and red. Seed, ash-gray with black dots. Diameter, 16 to 19 cm., length 44 to 44.5 cm., weight 6 to 9 kilos. (See Plate 1, fig. 1.)

Sta. Maria.—A strain claimed to have come from Meck. Almost globular in shape, medium size. Rind, dark-green 1 to 1.2 cm. thick. Ribbing, distinct and slight netting. Flesh, red, juicy, grainy and sweet. Seeds, dark-gray with black spots and easily removed. Diameter, 20 to 22.7 cm. Length, 21 to 23.5 cm. and weight, 4 to 5.2 kilos. Appeared in Candaba, Pampanga in 1918 (Plate 1, fig. 2).

"De Jaspe."—Described by Elayda in 1918 as a hybrid between Valencia and a certain white seeded American watermelon. Melon growers in Candaba, Pampanga, however, claim that it is a strain selection from Sta. Maria produced by them in 1928. Round and large. Rind, 0.6 to 1.3 cm. thick, green with distinct dark-green ribbing and light green netting all over the fruit. Flesh, pinkish to red with sweet flavor. Can not withstand long distance shipping. Seeds, pale brown to tan in color and adhere tightly in the flesh. Half-slip mature fruit has compact pinkish flesh but sour taste. Diameter, 17 to 19 cm., length, 19 to 19.2 cm. and weight, 2 to 3 kilos. (Plate 2, fig. 1.)

Magliston or De Liston.—A strain selected from "De Jaspe" produced in Candaba, Pampanga in 1933. The fruit is large and almost round. Rind, 1 to 1.5 cm. thick, light greenish with irregular green stripes. Scar at the staminate end is large and very conspicuous. Flesh, red, juicy and sweet. A small triangular cavity is found at the center as shown in the cross-section (Plate 2, fig. 2). Color of seeds, tan or light brown. Diameter, 22 to 24 cm., length, 23 to 24.2 cm. and weight, 4 to 6 kilos (Plate 2, fig. 2).

Ramie.—A new strain found among the "De Liston," having about the same shape, color but larger and heavier than "De Liston." Distinguishing characteristic is the dot-like scar at the staminate end. Produced in Candaba, Pampanga during the 1937–1938 season. Rind, similar to "De Liston," 0.8 to 1.3 cm. thick; diameter, 24 to 25 cm.; length, 25 to 28 cm.; and weight 7 to 8.5 kilos. Flesh, compact, juicy, red and sweet. Color of seeds, light greenish brown. Good shipping quality (Plate 3, fig. 1).

Sta. Rosa White.—Large, almost spherical and white-greenish color. Rind, 1 to 1.1 cm. thick, with light green netting and

almost indistinct shallow ribbing. Flesh, grainy, juicy, red and sweet. Not good shipping quality. Strain selection from "De Liston." Color of seeds, light brown. Diameter, 21 to 23.5 cm.; length, 22 to 27 cm.; and weight, 5 to 5.5 kilos (Plate 3, fig. 2).

THE SOIL

The soils in Candaba, Pampanga where watermelons are produced are clay-loam and sandy-loam. The place is visited by flood every year, causing the higher places to be depleted because of erosion while the section of lower elevation to become fertile due to deposit of alluvial soil. This is shown by the good harvest of watermelon at Pangatang and Kabigting, regions which are lower than Capitana Culasa, where yields are of inferior quality. Large areas of watermelon field in Candaba are newly cleared land. In the towns of Bocaue, Sta. Maria, Norzagaray, Bustos, Angat and Baliwag the watermelon fields are situated along the flood plains, (tumana) of the Angat River and the type of soil is sandy-loam. This place is inundated yearly thus receiving annual deposition of alluvial soil from the Angat River.

In this investigation rich sandy-loam soil has been found to be the best for watermelons but good crops have been produced also in clay-loam soil and on newly cleared land. Soil full of decayed vegetable organic matter and soil flooded every year, such as the soil on the swamp of Candaba, and on alluvial plains (tumana) along the bank of Angat River in Bulacan have been found good for watermelon production. However, fields that were continuously cropped with watermelon for several years showed decided decline in yields. Watermelon is often termed as a "clean-up" crop for it thrives best in newly opened and cleared land.

It is the consensus of opinion among planters that the land should be fairly fertile, has a source of good irrigation and at the same time good drainage in order that it may produce good melon.

PREPARATION OF THE LAND

In general, the method of preparing the land followed by the majority of the farmers in Candaba, Pampanga is poor. The majority of them plow the land only one time and without harrowing. The more progressive farmers, however, give two plowings and one harrowing before they plant the watermelon seeds. In Bulacan, on the other hand, the watermelon fields are prepared

thoroughly. The plowing is done three times and is harrowed thoroughly until the field is cleaned and in fine tilth. Furrows are well made unlike those in Candaba, where big clamps of soil are found after the preparation of the field.

Watermelon is not too exacting a crop as regards its culture, but like other crops it responds readily to good soil preparation. To put the land in fine tilth, plowing and harrowing should be two to three times at sufficient intervals before planting. In general the preparation of land for corn is similar to that for watermelon.

PLANTING SEASON DATES AND METHOD OF PLANTING

Planting season dates vary with the locality and the commencement of the dry season. In Candaba, Pampanga, planting begins from November to February while in Bulacan from the early part of October to December.

Planting distances have been found not to vary greatly in the different watermelon areas. A few growers in Candaba plant as close as 2 by 0.5 meters. Under this method plants were found to be prolific or heavy yielders but the fruits were small. Generally the distances of planting found best suited in the commercial watermelon producing centers was 2 × 2 meters with 2 to 3 plants being allowed to hill after thinning.

Before planting, the land is harrowed and then furrows of 2 meters far apart are made. At every 2 meters in the row, holes of 30 to 40 centimeters in diameter, 3 to 5 cm. deep are made. The seeds are then scattered and pressed lightly at every center of these holes, covered with earth by hand or with a hoe. Taking the distance of 2 × 2 meters, this arrangement gives approximaely 2,400 hills to the hectare. The farmers use 1½ gantas of seeds for one hectare. The farmers call this method of planting as the "balañga system," from the shape of the earthen jar "balañga."

As a general rule, to preven losses, planting generally commences soon after the heavy rains are over, because young seedlings are easily injured by heavy rains. From five to seven seeds are planted in each hill along the furrows, to insure a good stand of plants. Thinning of plants is started at the latter part of the second week, two to three healthy seedlings are left per hill. According to Beattle,(2) a second thinning should be done leaving if possible one seedling to the hill.

Elayda(1) reported distances of 3 to 2.4 meters, 3.6 by 3 meters or 3 by 3 meters, as being used in Pampanga and Bulacan but

put their crops in the market ahead of the others before the market is glutted in order to command higher price. This practice is not advisable, for to have a better flavor and good keeping quality, watermelons should be allowed to ripen on the vines like those produced in Sta. Maria, Bulacan. Fruits that are harvested green have a compact, tough and watery flesh, that is a little bit sour, while fruits ripened on the vines have granulated, spongy, sugary and red flesh. The latter are better appreciated by the consumers who demand good ripe fruits. With the use of knives the melons are severed from the vines (Plate 4, fig. 2) and these are gathered at once to be piled in a shed made for the purpose (Plate 5, figs. 1 and 2). As the harvesters continue cutting the fruits, the "Tote-boys" or pickers gather them in a loading point where a cart collects them for storage in the huts, located near the field.

Considerable complaints have arisen on account of the shipment of green melons to the market. In order not to destroy the confidence of the public, the growers of early crops should give more attention to the proper maturity of the melons grown. It has also been observed that the fruits are commonly pulled off from the vines. Knives and shears can be used for cutting melons from the vines. Care should be taken to leave the stem as long as possible. As the melons are cut off from the vines they are either carried direct to the huts or the loading center. The fruits should not be allowed to stand on their base-end either in the field or on carts. Care must be taken in laying the watermelons down, and in piling them one upon another carefully to prevent bruising.

GATHERING AND LOADING WATERMELONS

All available means of transportation are employed for hauling watermelons from the field to the loading center, ranging from small carts, big carts and trucks (Plate 5, fig. 4). The usual method of loading the melons from small piles to the carts or trucks is to have two men on the ground and one on the cart or truck and simply pass the melons one at a time, from the ground to the cart or truck. Growers use a piece of canvas to cover the load of watermelons to protect them from the hot sun or rain on the way to the huts in the loading place, and rice straw in the case of cart. From this loading center, they find their way to different markets.

METHOD OF MARKETING

Some growers sell their crops wholesale before their maturity. Others wait for their ripening before disposing of them. Prices of a hectare planted with watermelon depends upon the age of the plants, size and conditions of fruits. It varies from ₱300 to ₱500 during immature stage, and from ₱800 to ₱1,000 at harvest stage. The crops are also sold wholesale and retail. Wholesale buyers buy the whole pile in the loading center and take the produce to neighboring provinces and to Manila either by cascos or trucks. In loading centers it is a common sight to see sellers and buyers bargaining for prices. Market prices vary according to the condition and size of the crops and also to the existing demand and supply. Proximity to the market also determines price.

Watermelons are sold by the number, by the carload or by truckload, in which case sellers do much guessing in determining the price so as to gain in the trade. Local market in small lots also yield reasonable return. Some growers take their crop to other places for disposal while the majority await buyers in the field. Individual fruits are sold in the loading centers at from ₱0.15 to ₱0.30 depending upon the size. A cartload of melons sells from ₱10 to ₱15 at the town and a truckload of small melons sells at ₱55 to ₱70.

PESTS AND DISEASES OF THE WATERMELONS

Watermelons like any other crops are susceptible to many injurious insect pests and diseases. A number of pests and diseases have been observed in the watermelon areas covered. Rats, ants, melon aphids and dañgao (Pampango) *Ceretia similis* (Ol.) cause considerable damage and losses to the watermelon. In Pampanga the most common insect pests are the aphids and squash beetle, *Ceretia similis* (Ol.). These pests attack the plants when they are in the seedling stage. In Bulacan, black and red ants accompanied by the melon aphids cause high mortality among young watermelon plants, thus causing the farmers to hesitate to plant on a large scale. The presence of *Fusarium* wilt of melon in the watermelon fields of Candaba, Pampanga causes large amount of losses as it was responsible for the wiping out of almost 1,000 hectares of watermelon fields in 1937–1938.

No control measures are employed to check the ravages of these insects and diseases due perhaps to the ignorance of the farmers who just leave their plants at the mercy of these insects. Farmers in Candaba, however, keep a vigilant watch in their fields during the night, driving the squash beetle that attacks their plants. This is a phase of the industry that should be looked into by the provincial and municipal officials concerned.

GOOD SEEDS—ITS IMPORTANCE AND HOW OBTAINED

The value of good seed cannot be overemphasized, but the majority of the watermelon planters do not practice seed selection. The practice of selling their crops before maturity deprive them of the opportunity to select good fruits for seed. A common practice of the farmers is to sell the best marketable melons. Hence the important work of selecting and retaining good and sound fruits for seeds is not done.

The general practice in vogue is to get seeds from rotten fruits and from small ones left over in the field. This should be discarded as this will undoubtedly result in the degeneration of the varieties being planted, thus causing low yields in spite of the fertility of the soil. However, there are farmers who get their seeds from selected fruits.

For seeding purposes only 10 to 15 fruits are needed for every family and so farmers should mark enough of good melons from healthy and productive vines for their seeds before maturity or before harvest. Only the fruits of the desired color, type, size, etc. from vines free from pests and disease should be selected for seed purposes. They should be left to ripen fully on the vines. When harvested, the seeds should be removed from the meat, soaked in water for 24 hours, thoroughly washed and sun or air dried. These seeds should be stored in air-tight containers.

THE ECONOMICS OF THE INDUSTRY

The approximate area devoted to watermelon production in Candaba and San Luis, Pampanga, were arrived at by summing all the areas of their respective watermelon fields, while those in the towns of Bulacan were obtained from the agricultural reports of their Municipal Secretaries. The number of tenants were ascertained by the area of land a tenant cultivates in their respective towns. The gross income were obtained from persons in their respective town basing their estimates during the past four years.

TABLE 1.—*Approximate area of land under watermelon cultivation, approximate number of tenants engaged in the industry and approximate gross income in 1937–1938.*

Towns	Province	Approximate area	Number of tenants engaged	Approximate gross income
		Ha.		*Pesos*
Candaba	Pampanga	4,000–4,200	2,000–2,100	500,000–900,000
San Luis	do	25–30	25–30	
Bocawe	Bulacan	30–40	60–80	
Sta. Maria	do	135–145	270–280	3,000–5,000
Norzagaray	do	190–210	380–420	8,000–12,000
Angat	do	160–170	160–170	7,000–9,000
Baliwag	do	38–45	38–45	4,000
San Rafael	do	25–38	25–38	2,000–3,000
Bustos	do	135–145	270–290	2,000–6,000
Plaridel	do	10–15	20–30	
Total		4,748–5,045	3,248–3,483	526,000–935,000

According to Table 1, the approximate area of land planted to watermelon in the places surveyed, is approximately placed at from 4,748 to 5,045 hectares. The cultivation of these areas depends, however, upon the prevailing seasonal conditions. In Candaba, Pampanga the average size being worked by a farmer is 2 hectares, while in Sta. Maria, Bocawe, Norzagaray and Bustos, Bulacan it is one-half hectare for a farmer and for the rest of the towns it is 1 hectare. On the basis of these data, there are from 3,248 to 3,483 farmers working on the production of watermelon and on the average of 4 persons in a farmer's family because the majority of the farmers are married, there are from 12,992 to 13,392 individuals dependent upon the industry. This figure excludes the extra labor during the planting, harvesting, picking and transporting of the melons.

Table 2 shows the estimated amount of capital invested, labor involved, gross and net income per hectare of watermelon field.

GROSS INCOME

As already stated in previous paragraphs the gross value of one hectare of watermelon field depends upon the condition of the plants and stage of maturity of the fruits. The farmer's average gross income for one hectare of watermelon field if he sells wholesale when the plants are just commencing to fruit is ₱400, while if he waits and sells his fruits at maturity he gets ₱900. These conditions are based in the town of Candaba, Pampanga upon the actual sale as seen by the writer.

TABLE 2.—*Economic of production per hectare.*

Items of operation	Man days	Animal days	M—₱1.00 A— .50	Value
1. Cost of seeds, 1½ gantas at ₱0.50				₱0.75
2. Preparation of land:				
a. First plowing	7	7	1.50	10.50
b. First harrowing	2	2	1.50	3.00
c. Second plowing	5	5	1.50	7.50
d. Second harrowing	2	2	1.50	3.00
3. Furrowing	½	½	1.50	0.75
4. Planting	6		1.00	6.00
5. Cultivation and weeding	6	6	1.50	9.00
6. Harvesting:				
a. Picking	15		1.00	15.00
b. Gathering and hauling	15	15	1.50	22.50
7. Transportation expenses (contract labor, at ₱1—32 carts)				32.00
8. Watering expenses (contract labor)				20.00
9. Administration expenses				90.00
Total expenses				212.00
The farmer's gross return from 1 hectare at mature stage				900.00
Cost of production				212.00
The farmer's net income from 1 hectare of watermelon				688.00

NOTE.—The estimate of cost of production is subject to change, depending upon the cost of labor in the locality.

Production costs are generally high due to the need of a thorough preparation of the land, the subsequent cultivation, and attendant care of the plant. Estimated expenses from the preparation of the lands, planting, cultivation, watering including the cost of seeds, harvesting, picking, attendant care and the cost of transporting the melons is ₱212. In many cases owing to adverse conditions and other causes the cost of production becomes greater and the yield also becomes considerably lower. Contrary to prevailing opinions, the watermelons are not a cheap crop to produce, but the returns are reasonably high at the present rates of supply and demand. Taking the town of Candaba in Pampanga as an example, the gross receipt from its watermelon crop in 1936–1937 season reached to ₱500,000.

The only factors that are taken into consideration in this article in determining the cost of production per hectare are the costs of seeds, the expenses in the preparation of the land, cost of attendant care, supervision, harvesting and transportation. Interests on the value of land or rental, and interest on borrowed capital and other incidental expenses are not included. The depreciation charges on tools and the services of work ani-

mals are accounted for as the services of implements and animals are already evaluated.

FORMS OF TENANCY IN VOGUE

There are many forms of watermelon tenancy existing in Candaba, Pampanga. The most common of these are the following: (1) An uncleaned land is given to a farmer for a year or two for him to clean and raise watermelon. The farmer provides all the expenses but all gross income are his. For the second or third year, the farmer pays 12 to 15 per cent of the total return to the land owner, he, bearing all the expenses in the field. (2) Another system is for the land owner to provide the capital and share 50–50 on the income. (3) Still another system is for the land owner to lend capital to the farmer who pays him 12 per cent interest. Both share the cost of labor and split the net income. This is the form of tenancy in vogue in Bulacan which is also found in Candaba, Pampanga. (4) Many land owners, however, lease their land to the farmers for a definite number of years renewable for another term at the option of the onwer and farmer pays an stipulated amount in advance of the planting dates, or a certain rate on the return from the harvest.

SUMMARY

1. Watermelon is grown commercially in the towns of Candaba and San Luis, Pampanga and in nine towns of Bulacan for the local market and for the neighboring provinces, particularly the City of Manila.

2. There is at present an approximate area of 4,748 to 5,045 hectares devoted to the growing of watermelon in San Luis and Candaba, Pampanga and in the nine towns of Bulacan. These areas are in general worked out by tenancy system.

3. The approximate number of people that are dependent upon the watermelon industry is around 12,992–13,932.

4. The commercial varieties grown in Candaba, Pampanga are De Liston, Ramie and Sta. Rosa White, while in Bulacan—Sta. Maria, Meck, De Jaspe and De Liston are the ones grown.

5. Watermelon planting in Candaba, Pampanga begins from November to February while in Bulacan from the early part of October to December.

6. The approximate expenses for seed, and field operation to grow one hectare of watermelon is ₱212. The gross income,

however is big ranging from ₱300 to ₱500 and ₱900 per hectare, depending upon the stage of selling the fruits.

7. The watermelon crop is disposed either by selling it before maturity or wholesale after harvest.

8. The watermelon crop is subject to a number of insect and disease enemies. The most important disease observed was watermelon wilt. Aphids and squash beetle were also prevalent.

RECOMMENDATIONS

1. The land for the growing of watermelons should be thoroughly prepared.

2. Plant seeds that are of good quality, free from disease and are from good variety.

3. Never plant in land that was previously attacked by pests and diseases.

4. Harvesting and picking of watermelons should be done carefully by the use of knives or pruning shears.

5. Harvest fruits when they are vine-matured.

6. Pests and diseases should be controlled at their first sign of appearance.

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2. BEATTLE, WM. RENWICK. Watermelon. U. S. Dept. of Agr. Far. Bul. 1394. (1870.)
3. INFORMATION FROM GROWERS. Data supplied by them to the writer.

ILLUSTRATIONS

Plate 1

FIG. 1. The Meck variety. The almost total absence of ribbings and dark green color are characteristics of this variety.

2. Sta. Maria variety. Note the dark-green rind and the distinct ribbings, with slight nettings.

Plate 2

FIG. 1. "De Jaspe" variety. Wide dark ribbings and abundance of light green nettings. Note appearance of flesh, after long distance shipping.

2. "De Liston" variety. The name derived from the distinct stripes or liston. Note triangular hole at cross-section.

Plate 3

FIG. 1. Ramie variety. Exactly in appearance to the De Liston but heavier and compact.

2. Sta. Rosa White. Note poor keeping quality of fiber-like flesh.

Plate 4

FIG. 1. A partial view of a watermelon field.

2. A view showing a man harvesting fruits.

3. A view showing picking of harvested fruits.

4. A view, hauling watermelons to the shed.

Plate 5

FIGS. 1 and 2. Views showing storage of watermelons in the field.

3. A view transporting watermelons to the town.

4. A view where transported watermelons are unloaded. Note the trucks used for carrying watermelons to different places.

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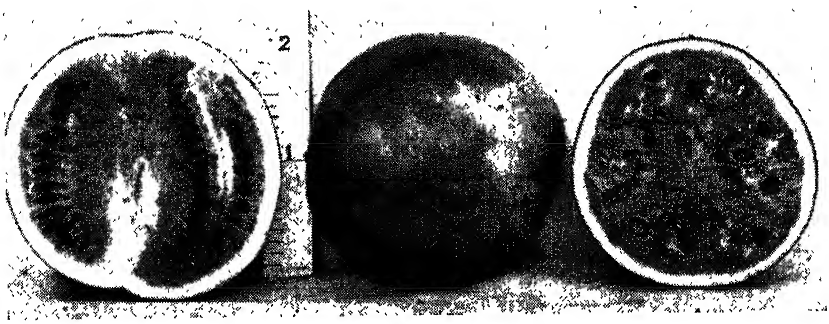

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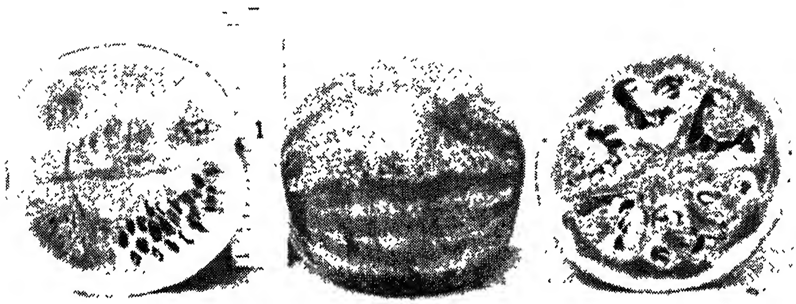
PLATE 1



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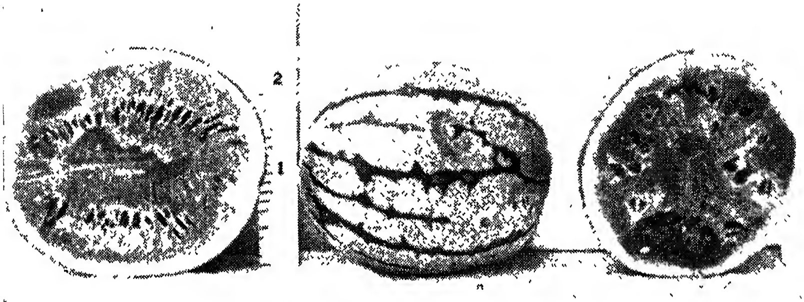

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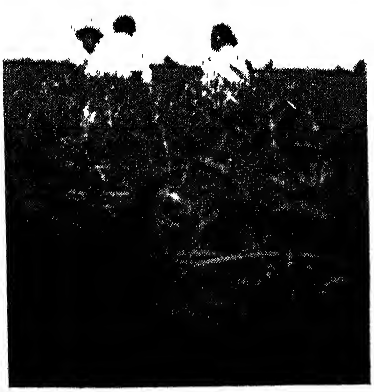

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PLATE 4

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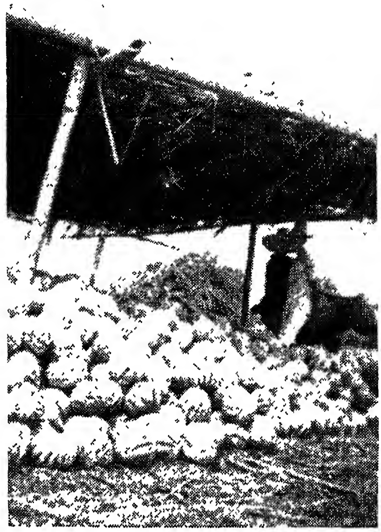

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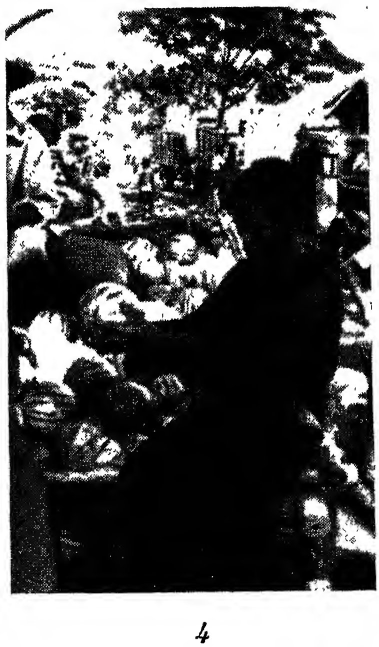

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PLATE 5

PALAGAD RICE CULTURE IN THE PHILIPPINES

Farmers' Circular No. 45

By Basilio R. Bautista
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TWO PLATES

The production of a lowland rice crop during the dry season or during the period between two regular wet-season rice crops is of utmost importance in the development of the Philippine rice industry.

Definition.—The term "palagad" literally means broadcast as it was first the practice to broadcast the rice seeds directly over the prepared field of off-season culture. But in this paper the term palagad means collectively all rice cultures during winter (December, January and February) and spring (March, April and May) whether broadcast or transplanted. Naturally in the growing of palagad rice, the supply of irrigation water is essential for success. In other regions where there is a pronounced maximum rain period in winter, the crop is for the most part dependent upon the rain.

Palagad culture is known in various provinces as "Panag-araw" or "Panag-arawan" in Bulacan, Cavite, and Rizal; "Palacaya" in Pampanga; and "Doble" in Sorsogon, but in Laguna where a large crop is raised, it is always called Palagad.

Varieties maturing from March to June when planted during the period from November to March are called palagad rices. Some varieties when planted from February to March mature in July and August, hence they are too long maturing to be included in the palagad group. The palagad varieties may be planted also in the regular wet season but generally are poor yielders, except Guinangang that do as well in the rainy season as in the dry season.

The plasticity in rice gives rise to the formation of thousands of varieties adapted to different conditions(2). It is assumed that the palagad system of cropping was accidentally discovered in some irrigated areas by means of rice volunteers which grew out of season from the rice seeds that dropped to the ground

during the harvesting of the regular crop. The plants, of course, developed normally and gave satisfactory yield during the dry season.

The palagad crop of lowland rice is a sure additional income which may cover the irrigation fees, land tax and the supply of the family's rice to last up to the next harvesting season of a regular-season crop. It ameliorates the living condition of indigent farmers especially on areas that are affected by flood and typhoon.

Soil.—The best soil for palagad rice is clay to clay loam underlaid by a hard pan which retains irrigation water that will maintain the crop to the dough stage.

Seedbed.—An ordinary seedbed prepared by one plowing followed by three to four harrowings with intervals of several days to last 15 and 16 days, may be used. The size of seed bed varies from 333 to 400 square meters for 25 gantas of seeds, enough to plant a hectare. Of course, fertile soil should be selected for seedbeds. The seeds before broadcasting in the seedbed should be soaked overnight and drained for 24 hours to start germination. In regions where there is a long dry season such as in Central Luzon, the seedbed is kept moist to prevent the stunting effect of soil cracking. In places with more humid climate, soil cracking is not common, nevertheless, should the soil show indication of cracking, a moderate irrigation to keep the soil in a saturated condition is essential. The seedlings in the seedbed during the palagad season are less vigorous than those grown at the beginning of the rainy season. A top dressing of about 100 kilograms of ammonium sulphate per hectare will invigorate the seedlings. The seedlings are ready for transplanting at the age of 5 to 6 weeks or younger depending upon the vigor of the seedlings.

In Laguna Province, the "dapog" seedbed is the kind most commonly employed. The method is advantageous as it saves time, space and possibly labor. There are two ways of preparing the "dapog" seedbed. (*a*) The ground is prepared in the ordinary way, by plowing once and harrowing just to puddle and level it. Whole banana leaves (torn leaves patched up), are laid one layer on the surface with the sides overlapping each other, and the prominent midribs down-ward. This layer prevents the roots or rootlets of the seedlings to penetrate into the ground. Pressing the leaves downward carefully will accumulate a thin layer of mud about two centimeters thick for

the seeds to grow on. The seeds, soaked and drained for 36 hours, are then sown. (*b*) Another way which is slightly different from (*a*) consists in putting whole banana leaves on the top of a clean and level ground, and then covering it with either sand or fine chops of rice straw to a thickness of about two inches. Rice husk should not be used as it may harbor organisms that will affect the rice seedlings.

If chopped straw is used, a thin dressing of sand is necessary to cover the interspaces between the chopped straw. After the seeds are sown, a very thin layer of either sand or soil is laid on top to cover the seeds.

On account of the small size of the seedlings to be transplanted, (from 6 to 8 seedlings per hill), an amount of no less than 30 gantas of seeds with good germination is necessary to plant a hectare. A hectare lot requires a seedbed of from 40 to 50 square meters in the form of strips of one meter wide with sufficient length to accommodate the seeds.

Direct broadcasting.—It is a general practice in Pampanga and Bulacan and to a certain extent in Cavite and Laguna to plant direct, by broadcasting, the seeds. However, it has been found by experimentation that the transplanted crop produced from 15 to 20 per cent more than the crop planted by broadcasting.

To avoid hand sprinkling, the seedbeds should be located where irrigation water is available.

Age at transplanting.—The seedlings under the "dapog" system are ready for transplanting from 9 to 12 days after sowing and 5 to 6 weeks under regular seedbed, or just before the node formation of the plants takes place. While in the seedbed the seedlings are kept watered by hand, sprinkling twice a day, morning and afternoon.

Care of the crop.—During hot days the plants are subject to the scalding effect of hot water specially before the plants reach a height of 20 to 25 centimeters. The irrigation water then should be applied in a flush, just enough to saturate the paddies. Even under a more humid climate obtaining in certain rice sections of the Islands, irrigation by flushing should be practised so as to preclude the possibility of drowning the young plants at tender age. When the plants are large enough to shade the entire field, the water may be increased gradually to maintain the crop till just before the dough stage when the water should be released.

Selection of palagad varieties.—One important factor to be considered in the growing of palagad rice is the proper selection of varieties that are suited to different soil types. It has been found that the only variety of rice that is extensively planted in the province of Laguna is Guinangang. Varieties Sipot, Dinagat, Sinadyaya, Inintiw, and Binicol are also planted in commercial scale but the Guinangang variety leads in the area planted and in production. The soil type on which Guinangang, Sipot, Sinadyaya and Dinagat are planted is a heavy clay loam type.

The variety Mangasa is the only variety that is commercially grown in Cavite. The soil type in that province is also of a heavy clay loam but much poorer in fertility than that of Laguna. By way of distinction between palagad Mangasa in Cavite and upland Mangasa in Rizal Province, the former variety has slender stalks and longer type of grains and can be planted also as upland rice while the upland Mangasa from Rizal is purely upland and does not produce grain crop under palagad culture. The upland Mangasa has coarser stalks and much more plump grains than palagad Mangasa.

The variety commonly planted in commercial scale in Pampanga is Pinursigue, an upland variety grown in Batangas Province. In certain sections where the soil is sandy clay loam as in Lubao, the variety Kinawayan is planted. Way back in 1932, the Bureau of Plant Industry started a commercial planting of Guinangang and trial planting of Sipot, Sinadyaya and Kinawayan in Albay Province. The reports received from that province states that Kinawayan is gaining popularity among the rice planters there after five years of trial planting and extension work. In Albay the soil is of volcanic origin with predominating sandy clay loam type, and a clay sub-soil. This corroborates the finding in Lubao, Pampanga.

In 1935 the writer investigated the possibilities of palagad rice culture in Nueva Vizcaya. The varieties found growing in small spots were Pinursigue and Sipot, and were giving the planters encouraging results. The Guinangang variety from Laguna Province was introduced. The success of the crop was amazing (Plates 1 and 2). The soil type in Nueva Vizcaya varies from light clay loam to heavy clay loam. The place where the palagad varieties had been tried is about 2,000 feet above sea level. As to soil type, it is similar to that of Laguna.

In Hagonoy, Bulacan, the variety Pinursigue is planted in a commercial scale. The soil in Bulacan is of hydrosol type(1). The place is annually flooded by the Pampanga River. There is no regular irrigation system except the rising of high tide that cause the water in the river to overflow its bank and irrigate the field. The water is saline or brackish in nature. Other varieties such as Balibod, Macan Aga (local variety), Macan Señora (local variety), Dinolaro, Binuhañgin or Milagrosa and Magsangle are propagated in small scale because the farmers like them, but the general variety raised is Pinursigue which perhaps can best stand under brackish condition. Other places in the Philippines having similar conditions obtaining in Hagonoy, Bulacan, may be able to raise palagad rice.

In the towns of Cardona, Morong, Baras and Tanay in Rizal Province, the general variety used is Kaawa. Guinangang was tried and gave better crop than Kaawa, but it did not attract wide attention for it matures longer than Kaawa. Trial of Sinadyaya was, however, made and one planting gave a yield of 86 cavans to the hectare which, of course, needs further verification. The soil in these places is rich, belonging to Bay clay loam type(1). The soil is a deposit of the Laguna Lake water consisting of well decomposed organic matter. As the lake subsides in coincidence with the dry season, the land is planted and irrigated by river water.

For almost a decade and a half, the defunct Alabang Rice Experiment Station, Alabang, Rizal, had been conducting series of researches on palagad varieties. Of the several hundred varieties tested by the Bureau, only about 20 varieties proved to be amenable to palagad culture. The outstanding seven varieties as regards yield are Sipot, Dinagat, Magsangle, Mangasa, Sinadyaya, Binicol, and Guinangang Str. 1.

DESCRIPTION AND PERFORMANCE OF THE PALAGAD RICE VARIETIES TESTED

Sipot.—This variety is a pure strain isolated from a variety known as Binuhañgin in Siniloan, Laguna. The tillering capacity is fair with medium strength of culms. The variety matures in 155 days. The mean yield is 49.2 cavans per hectare. The eating quality is fair. The yields are shown in Table 1.

TABLE 1.—*Yield of Sipot at the Alabang Rice Experiment Station, Alabang, Rizal, 1921–1932.*

Year tested	Yield per hectare	Year tested	Yield per hectare
	Cavans		*Cavans*
1921	10.0	1927	69.7
1922	29.3	1928	65.9
1923	50.9	1929	55.0
1924	59.4	1930	----------
1925	50.0	1931	47.8
1926	55.2	1932	47.1

Dinagat.—It is an early variety, maturing in 146 days. This variety used to be popular in Calamba, Laguna. The grains are highly shattering and should be harvested before fully matured. The stooling is fair and the culms are stiff. The eating quality is good. The average yield is 38.5 cavans to the hectare (Table 2).

TABLE 2.—*Yield of Dinagat at the Alabang Rice Experiment Station, Alabang, Rizal, 1923–1927.*

Year tested	Yield per hectare	Year tested	Yield per hectare
	Cavans		*Cavans*
1923	32.1	1926	28.4
1924	44.7	1927	52.6
1925	34.6		

Magsangle.—This matures in 134 days, the earliest among the palagad varieties tested. The tillering capacity is poor and the culms are weak. The cooked rice is rather insipid. Its average yield is 28.4 cavans to the hectare as shown in Table 3.

TABLE 3.—*Yield of variety Magsangle at the Alabang Rice Experiment Station, Alabang, Rizal, 1921–1927.*

Year tested	Yield per hectare	Year tested	Yield per hectare
	Cavans		*Cavans*
1921	8.2	1925	10.0
1922	22.5	1926	49.4
1923	24.6	1927	44.9
1924	39.2		

Mangasa.—This variety is early maturing, 138 days. The tillering habit is rather fair and the culms are fairly stiff. The eating quality is fair. The yield is 39.2 cavans per hectare as shown in Table 4.

TABLE 4.—*Yield of Mangasa at the Alabang Rice Experiment Station, Alabang, Rizal, 1919–1932.*

Year tested	Yield per hectare	Year tested	Yield per hectare
	Cavans		*Cavans*
1919	20.0	1926	44.2
1920	59.2	1927	50.1
1921	40.0	1928	21.1
1922	----------	1929	39.2
1923	45.5	1930	44.4
1924	45.2	1931	30.2
1925	31.6	1932	39.7

Sinadyaya.—It matures in 140 days. The stooling capacity is fair. The culms are medium stiff, and the heading is rather irregular. The performance record on experimental plots at Alabang is 42.5 cavans to the hectare as shown in Table 5.

TABLE 5.—*Yield of variety Sinadyaya at the Alabang Rice Experiment Station, Alabang, Rizal, 1927–1932.*

Year tested	Yield per hectare	Year tested	Yield per hectare
	Cavans		*Cavans*
1927	58.3	1930	35.3
1928	51.9	1931	29.7
1929	48.7	1932	31.1

Binicol.—This is an upland variety which is also used as palagad rice. Under palagad conditions, Binicol matures in 152 days and is not as good as in the upland. It requires very little amount of irrigation water applied to a saturation point only. This condition encourages thick weed growths. Because of its poor adaptability under lowland condition, from 30 to 35 gantas of seeds are needed to plant a hectare. The planting is by broadcasting. The grains are highly shattering. This is planted for fancy rice only, the grains being aromatic.

The average yield is 35.3 cavans per hectare as shown in Table 6.

TABLE 6.—*Yield of Binicol at the Alabang Rice Experiment Station, Alabang, Rizal, 1919–1927.*

Year tested	Yield per hectare	Year tested	Yield per hectare
	Cavans		*Cavans*
1919	13.0	1924	58.2
1920	48.4	1925	34.4
1921	----------	1926	35.4
1922	26.1	1927	39.8
1923	27.4		

Guinangang strain.—This is an isolated strain from the variety Guinangang commercially planted as palagad crop in Laguna Province. It is a dual purpose variety, as palagad and as regular season crops. It can be planted in any part of the year provided that there is water. The tillering capacity is fair, and the culms are stiff. It matures in 159 days. The eating quality is fair. The marked difference of the selected Guinangang and its original stock is that the grains of the former are straw colored with dark brown shade, while the grains of the original stock are also of straw color with slight brown shade, and of semi-bearded type. The average yield is 56.7 cavans per hectare and its record of yields is shown in Table 7.

TABLE 7.—*Yield of variety Guinangang Str. 1 at the Alabang Rice Experiment Station, Alabang, Rizal, 1928–1932.*

Year tested	Yield per hectare	Year tested	Yield per hectare
	Cavans		*Cavans*
1928	72.7	1931	56.0
1929	51.9	1932	48.4
1930	54.8		

The performances of the varieties described above are summarized in Tables 8 and 9. Varieties under Table 8 are early maturing varieties and varieties under Table 9 are late maturing varieties.

TABLE 8.—*Performance of early maturing varieties.*

Variety name	Number of days to maturity	Yield per hectare
		Cavans
Dinagat	146	38.5
Mangasa	138	39.2
Sinadyaya	140	42.5
Magsangle	134	28.4

The early varieties are enumerated in the order of their yielding capacities: Sinadyaya, 42.5 cavans per hectare; Mangasa, 39.2; Dinagat, 38.5; and Magsangle, 28.4 cavans per hectare.

TABLE 9.—*Performance of late maturing varieties.*

Variety name	Number of days to maturity	Yield per hectare
		Cavans
Guinangang	159	56.7
Sipot	155	49.2
Binicol	152	35.3

In the late maturing group, Guinangang Str. 1 is the highest yielder, producing 56.7 cavans per hectare, and Sipot is second, yielding 49.2 cavans per hectare and Binicol is the poorest yielder, giving 35.5 cavans to the hectare.

Palagad rice varieties for different provinces.—The various types of climate and soils in the different parts of the Islands make it difficult to determine new varieties suitable for planting in any one district or province. In regions affected by pronounced wet and dry season, the late maturing varieties are better yielders than the early maturing ones. The harvest of the crops takes place after the dry season has begun. But in regions where there is no dry season or there is only a short dry period, the late maturing varieties are liable to get wet and be spoiled by the rain, consequently it is preferable, as indeed it is the general practice, to plant short-season varieties in such regions.

In Table 10 are given the names of the provinces and the varieties of palagad rice that are already grown there. Also other varieties which are likely to be adapted have been added.

Fertilization and green manuring.—Continuous cropping of lowland rice on the same land exhausts soil fertility. The crop can be brought to normal by the application of a mixture of 150 kilograms each of ammonium sulphate and single superphosphate per hectare. It is applied when the paddies are in saturation point or drained. Weeding is necessary in order to give the rice plants the full benefit of the fertilizers.

Green manuring may substitute chemical fertilizers. Tapilan and mongo, according to analysis made by the Bureau of Science, Manila, contain the necessary elements (Table 11). The planting of legumes such as mongo and tapilan could be

made immediately after the rice harvest, at the rate of 14 to 16 gantas per hectare. The crop at blooming stage should be completely plowed under in order to obtain the best results.

TABLE 10.—*Varieties of Palagad rice for each of 20 provinces.*

Provinces	Varieties recommended for palagad planting
Agusan	Sinadyaya, Kaawa, Mangasa, and Dinagat.
Albay	Kinawayan, Guinangang, Sipot, and Kinarlos.
Antique	Guinangang, Sinadyaya, and Mangasa.
Bataan	Guinangang, Sinadyaya, and Dinagat.
Bulacan	Guinangang, Sipot, Sinadyaya, Kaawa, Pinursigue, and Mangasa.
Cagayan	Guinangang, Sinadyaya, and Mangasa.
Camarines Norte	Kinawayan, Guinangang, Sipot, and Baranay.
Camarines Sur	Kinawayan, Sinadyaya, Kaawa, Baranay, and Kinarlos.
Capiz	Sinadyaya, Guinangang, and Mangasa.
Cavite	Mangasa and Sinadyaya.
Cebu	Sinadyaya, Mangasa, and Dinagat.
Laguna	Guinangang, Sipot, Sinadyaya, and Dinagat.
Leyte	Sipot, Sinadyaya, and Mangasa.
Nueva Vizcaya	Guinangang, Sipot, and Pinursigue.
Pampanga	Kinawayan, Pinursigue, and Balibod.
Pangasinan	Sipot, Guinangang, and Sinadyaya.
Rizal	Kaawa, Sinadyaya, and Guinangang.
Sorsogon	Kinawayan, Guinangang, Sipot, Sinadyaya, and Baranay.
Tarlac	Guinangang, Sipot, Kinawayan, Sinadyaya, and Pinursigue.
Tayabas	Sinadyaya, Mangasa, and Kinarlos.

TABLE 11.—*Fertilizing value of mongo and tapilan.*

Legume	Amount of materials per hectare			
	Amount of dry matter	Nitrogen	Phosphoric acid	Potash
	Kilos	*Kilos*	*Kilos*	*Kilos*
Mongo	3,895.98	97.79	18.30	22.95
Tapilan	4,394.94	98.53	21.97	33.41

Pests and diseases.—The most common enemies of palagad rice are the rice bugs, *Leptocorisa acuta,* Thumberg; leaf folder caused by the larvæ of *Chaphalocrosis medinalis,* Guen.; rice stem-borer caused by the larvæ of a moth, *Schœnobius incertellus,* Wlk.; maya birds, *Munia jagori;* brown rats, *Rattus norvegicus;* leaf spots, *Helminthosporium oryzea,* V; Breda de Haan, etc. Of the most destructive pests of palagad crop are rice bugs, rice stem-borer, rats and birds. No serious losses due to diseases are recorded, however.

SUMMARY AND RECOMMENDATIONS

For palagad rice farming under any type of climate in the Philippines, sufficient irrigation water should be available to maintain and develop the crop to the dough stage.

1. For good results, transplanting rather than broadcasting should be practised.
2. Under limited supply of irrigation water, use only early varieties such as Dinagat, Mangasa, Sinadyaya and Magsangle (short season).
3. Under liberal supply of irrigation water, plant Guinangang and Sipot and if desired, early varieties such as Dinagat, Mangasa, Sinadyaya and Magsangle may as well be planted.
4. For quality or fancy rice, Binicol may be planted.
5. The Guinangang variety can be planted in any part of the year on places provided with irrigation water where the crop will not be affected by floods and other adverse factors.

ILLUSTRATIONS

PLATE 1

Palagad rice of Guinangang variety at heading, Bambang. Nueva Vizcaya.

PLATE 2

A portion of a field of Guinangang. Plants bend down under a heavy burden of grains.

PLATE 1

PLATE 2

METHODS OF PROPAGATION AND PLANTING

The plant can be propagated by seeds and by cuttings.

It is very productive, and so remarkably instantaneous in growth that in districts like Tondo, Manila, where congestion practically leave no room for the pursuit of gardening in the premises, the talinum can readily be raised in window boxes or in cans (Plate 1, Fig. 3).

If the seeds are used, they are sown in boxes or in a small plot in the ground (Plate 1, Fig. 1). In the latter case, they are sown in rows about 30 centimeters apart, and the seedlings are either pricked or planted direct into permanent plots in the fields, at distances of 1 meter in rows 1 meter apart. These distances will render cross cultivation possible while the plants are young or until the crop has attained considerable size.

As the plant is conveniently and quickly produced by using cuttings, this method of propagation is preferred to that of seeds. Cuttings (Plate 3, Fig. 3), 15 to 20 centimeters long, are prepared from any portion of the plant from the main stem or branches, as both young and old parts will grow. Precaution should be taken to remove all leaves from the cuttings before planting, in order to avoid rapid transpiration which drains the cuttings of. their vitality and causes them to die. The same distance of planting observed in the case of transplanting seedlings described above, holds true in the case of cuttings, i.e., setting the cuttings 1 meter apart in the row and 1 meter between rows. The cuttings are planted in the center of the furrows in a slanting position to a depth of 8 to 10 centimeters. As previously stated, the distance of 1 meter between furrows facilitates cultivation which should be done about two or three weeks immediately after planting.

Trials at the Economic Garden have indicated that talinum can be grown feasibly in all seasons of the year but requires a soil sufficiently rich in humus.

HARVESTING THE TOP-ENDS AND THE SEEDS

After six or seven weeks from the date of planting, several lateral branches are produced and harvesting of the top-ends or young shoots (Plate 4, Figs. 1, 2 and 3) can be fairly started. This is done by simply breaking off the young, tender top-ends from the branches.

In order to obtain seeds, a few plants are to be left alone, i.e., the top-ends are not harvested from them, so as to allow the flowers to develop and the carpels to mature.

As soon as the flowers start to fall off, the light colored carpels or fruits (Plate 3, Fig. 1) are primed for harvest. These carpels are brittle and can be crushed between the fingers so as to liberate the seeds. When the plants have produced numerous branches which become so dense, the old plants are ready to be replaced with new ones by planting cuttings or seeds (Plate 3, Fig. 2) obtained from the mother plants.

COST OF PRODUCTION AND YIELD

The operations involved in the preparation of land for the planting of talinum on a commercial scale are practically identical with that of planting sweet potato. It is estimated that a hectare of this crop would yield about 12 tons of the young shoots, at the rate of 1.2 kilos per plant, or a gross return of approximately ₱1,200 per annum per hectare. Of course, it is to be expected that the ease of production may clog the market and lower the price very promptly.

UTILITY OF THE PLANT

Talinum, besides being an ornamental and pot-herb (Plate 1, Fig. 2), is an excellent source of greens (gulay), and contributes materially to a properly balanced diet of the people. Analysis of the young shoots or top-ends gives 91.26 per cent water, 1.56 per cent ash, 0.80 per cent crude fiber, 1.23 per cent protein, 0.45 per cent fat, 4.70 per cent carbohydrates, and 277 calories per kilo of food.

The Plant Utilization Division of the Bureau of Plant Industry has extensively experimented on the preparation of talinum for the table and has evolved at least 80 recipes using talinum as the main ingredient. The said Division found the following facts about talinum:

It is easily prepared; it seems to keep longer than many other leafy vegetables; it has no raw vegetable flavor which is present in many vegetables and which is eliminated by cooking; it combines satisfactorily with meats, fishes, mollusks, and other vegetables and, therefore, makes a good soup, a delicious salad, a main dish, and a satisfactory dessert. One advantage of the talinum over some common leafy vegetables is that it can be served raw, blanched, or cooked. When served raw, it is strongly recommended that it be soaked in a dilute lime solution for

a period of between 5 to 10 minutes to be sure that it is safe.

Some of the popular recipes for talinum are as follows:

TALINUM SINIGANG

1 cup talinum
2 cups rice water
1 medium sized bañgos (cut into 4 pieces)
4 tomatoes, regular size
10 camias, large
2 hot peppers
1½ teaspoonfuls salt

Boil tomatoes and camias in rice washing until soft. Add hot peppers and salt; then add the fish. Let it simmer until fish is done. Add talinum before serving.

TALINUM BULANGLANG

1 cup talinum
1 eggplant (cut to pieces)
1 amargoso, medium size (cut to pieces)
½ cup string beans (cut 1 inch long)
½ bañgos or dalag, broiled
1 tablespoonful bagoong
2 segments garlic
1 table spoonful lard
¾ cup rice water

Sauté garlic and bagoong. Add string beans, amargoso, and eggplant. Add fish, then the boiling rice washing. Let boil for 5 minutes. Add talinum before serving.

TALINUM PINACBET

2 cups talinum
3 teaspoonfuls bagoong
1 small tomato, sliced
1 small onion, sliced to pieces
⅓ cup "chicharon," broken to small pieces
⅓ cup stock

Place tomato and onion together with the bagoong in the stock. Boil and add the washed talinum and the "chicharon" a few minutes before serving.

GULAY

1½ cups talinum
1 cup cassava (fresh) sliced into narrow strips
¼ cup shrimp
¼ cup pork (cut to pieces)
1 segment garlic
1 tablespoonful lard
2 cups shrimp and pork stock

Sauté garlic; add pork and shrimp previously boiled in $2\frac{1}{2}$ cups water. Add stock and let boil. Add cassava and boil 5 minutes. Add talinum before serving. Serve hot.

TALINUM PULUTAN

1 cup talinum
$\frac{2}{3}$ cup green mango
$\frac{1}{3}$ cup tomatoes
3 tablespoonful patis

Soak talinum in lime solution for 10 minutes. Rinse with drinking water to remove excess lime. Slice crosswise to about $\frac{1}{4}$ inch wide. Cut tomatoes to small cubes and the mango to very small pieces. Mix all ingredients.

(Lime solution may be made by dissolving 1 teaspoonful of lime (CaO) in about 2 quarts of water.)

ILLUSTRATIONS

PLATE 1

FIG. 1. Two plots of talinum in the nursery of the Los Baños Economic Garden, Los Baños, Laguna.
2. A talinum plant growing in the open field.
3. A talinum plant growing in a petroleum can.

PLATE 2

FIG. 1. Sketch of a young shoot of talinum.
2. Diagram of inflorescence of talinum.
3. Sketch of talinum flower.
4. Vertical section of the flower of talinum.
5. Horizontal diagram of the talinum flower.
6. Sketch of the side view of a carpel of talinum.
7. Vertical section of a carpel of talinum.

PLATE 3

FIG. 1. Capsules (carpels) or fruits of talinum newly harvested for curing.
2. Seeds of talinum.
3. Stem cuttings of talinum, at various stages, for planting.

PLATE 4

FIG. 1. Young shoots of newly harvested talinum for food.
2. Young shoots of talinum being prepared for shipment, using banana sheaths.
3. Young shoots of talinum packed for the market.

1

2

3

PLATE 1

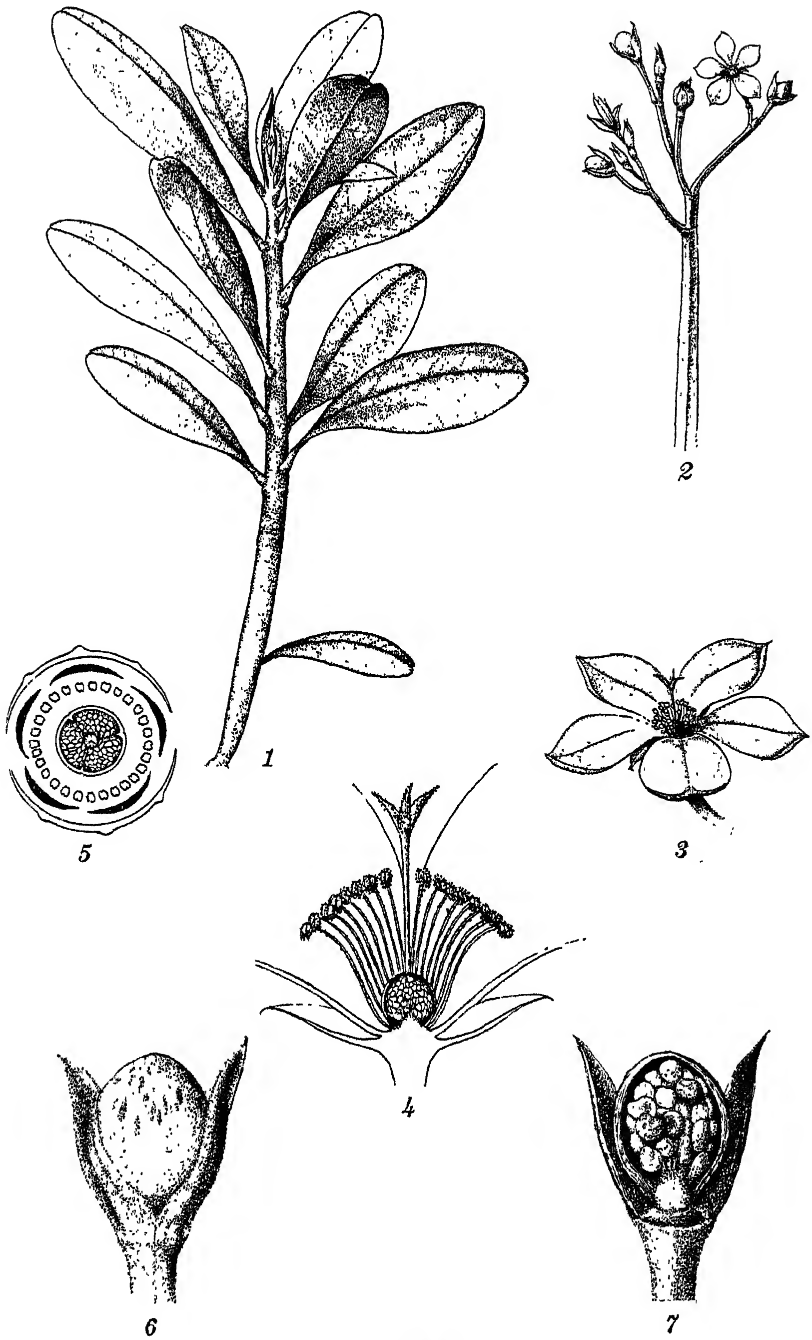

PLATE 2

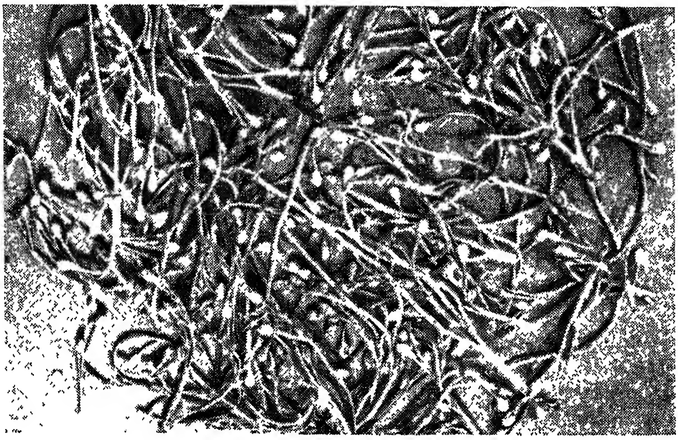

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PLATE 3

1

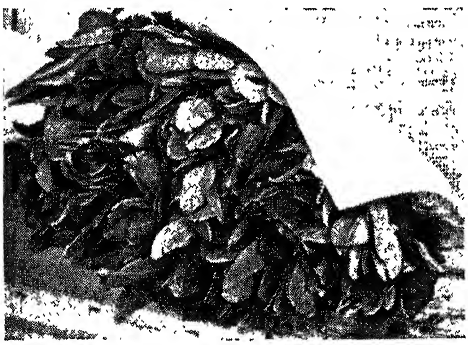

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PLATE 4

EGGPLANT DISEASES AND THEIR CONTROL

(Farmers' Circular No. 44)

By MACARIO A. PALO
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SEVEN PLATES

Eggplant is one of our important and popular vegetable crops in the Philippines. It is found in almost every home garden and in some places, it is grown on a large scale for shipment to nearby markets. Owing to increased hectareage, its production has risen from 10,170,600 kilos valued at ₱387,140 in 1933 to 10.800,120 kilos valued at ₱421,520 in 1936. The average production by weight of eggplants per hectare in the Philippines is low, being only about one-fourth of that of the United States and probably lower than that of India, China, and Japan.

One of the causes of the low production of eggplants in the Philippines is the attack of diseases. With the widespread distribution and continued planting of eggplants, diseases were gradually introduced and have become more firmly established in places where they are grown frequently on the same land. Now, some of these diseases are considered the main limiting factors in profitable commercial eggplant growing in the Philippines. There are times when they cut down the yield to about 10 to 50 per cent or ruin the entire crop in certain places. Their destructiveness is enhanced by warm, moist weather, thus, their outbreaks are often more severe during the wet months than during the dry months of the year. Greater loss is experienced by the growers when two or more diseases (Plate 1, figs. 1 and 2) occur in the same field.

The diseases which are commonly observed to be destructive on eggplants in the Philippines are damping-off, bacterial wilt, Phomopsis disease, Phytophthora disease, root-knot and stem-rot. The other diseases of eggplants such as leaf-spot, rust and anthracnose have been reported in the Philippines but they have not been observed to occur in an alarming proportion.

Serious outbreaks of eggplant diseases could be prevented and considerable amount of loss could be reduced if the growers

are acquainted with their nature and their cause, the factors affecting their outbreaks and the simple practical methods of stemming their ravages. It is, therefore, the purpose of this circular to bring together for the benefit of eggplant growers all of the important and useful information concerning eggplant diseases and their control.

MAJOR EGGPLANT DISEASES

DAMPING-OFF

The disease known as damping-off is the most common and most destructive of all seedbed diseases of eggplants. The disease is not caused by dampness as its name implies but by a number of parasitic organisms which develop under damp conditions.

Symptoms.—The disease can readily be recognized by the falling-over or wilting of young eggplant seedlings (Plate 2, fig. 1). Upon examining the affected seedlings it will be observed that the parts of the stems at or near the level of the ground are water-soaked. The disease in the seedbed usually begins in few spots which gradually spread in more or less circular form. The seedlings may all be destroyed if the existing conditions continue to be favorable for the spread of the disease. A thin cobweb-like growth of the causal fungus may be seen on the surface of the soil and on plants which have fallen over. As the seedlings grow older and become more woody they become more resistant to the disease. Very often the seedlings outgrow the disease. Such seedlings may look normal but commonly their stems are constricted or may show sunken, brown scars at points of infection.

Cause.—Damping-off of eggplant is commonly caused by either a soil-borne fungus known as *Rhizoctonia solani* Kuhn, or by a seedborne fungus known as *Phomopsis vexans* (Syd. & Sacc.) Harter. *Sclerotium rolfsii* Sacc., another common soil-inhabiting fungus, also causes damping-off of eggplant (Plate 2, fig. 2) but it is seldom observed in seedbeds. *Rhizoctonia solani* and *Sclerotium rolfsii* are capable of living in the soil as saprophytes feeding on organic matter and when favorable conditions occur they become active parasites. They are also capable of passing over an unfavorable weather by means of specialized fungus bodies known as sclerotia.

Control.—Sterilization of the soil is one of the surest ways of controlling the damping-off organisms in seedbeds. To be ef-

fective, it should be made thorough, to make sure that the damping-off fungi are all killed. Soil sterilization can be accomplished by either steam, surface-firing, roasting or chemicals. Formalin (one part of commercial formalin to fifty parts of water) applied at the rate of about 1.5 liters to one square foot of soil in seedbeds is the usual amount of chemical used in sterilizing soil. Only healthy seeds should be planted because no amount of sterilization can rid the seedbed of damping-off caused by *Phomopsis vexans* if the seeds are contaminated with this fungus. Where soil sterilization is not feasible, eggplant seedlings can sometimes be grown successfully in seed flats containing virgin soil or any soil that has not been cultivated. However, there is no assurance that such soils are always free from damping-off fungi.

Crowded planting in seedbeds should be avoided because it creates a condition that promotes rapid growth and spread of damping-off organism. The beds should be located where they could be exposed to the sun during a certain part of the day so as to dry off the excessive moisture in the soil and prevent the rapid development of damping-off fungi. Frequent stirring of the soil between rows of seedlings is also beneficial in checking the disease. If a certain part of the seedbed becomes infected, the healthy seedlings may be saved by pricking them out into new beds or by removing the soil and plants in the infected area completely out of the seedbed.

BACTERIAL WILT

The bacterial wilt is the most serious disease of eggplants in the field. Wet weather coupled with high temperature is most conducive to its development and rapid spread. During such weather many plants perish and the disease usually assumes an epidemic proportion.

Symptoms.—The bacterial wilt attacks the eggplant at any stage of its growth in the field. The most conspicuous symptom of this disease is the wilting of the foliage which may first be observed a few weeks after transplanting the plants in the field. The early indication of the presence of the disease is the drooping of a number of leaves on one or more of the branches (Plate 3, fig. 1). The veins and midribs of affected leaves become soft and limp and the tissues between the veins become pale green or brown. Gradually, more branches are involved until wilting becomes prominent (Plate 3, fig. 2). Plants which show only

partial wilting recover during the night when transpiration is low. When the stem of a wilted plant is cut across, the woody part shows brown discoloration. The discolored parts are the water-conducting vessels filled with bacteria whose presence interferes with the free movement of water and food materials from the roots to the leaves, ultimately resulting in the wilting of the plants. On pressing the cut stem, a slimy dirty-white matter which is composed mainly of bacteria, oozes out of the cut end.

Cause.—This disease is caused by *Bacterium solanacearum* E. F. S. = *Phytomonas solanaceara* (E. F. S.) S. A. B. The organism gains entrance into the plant mainly through injuries caused by insects and nematodes and wounds inflicted upon the roots during transplanting and cultivating the plants. Within the host tissues the bacteria multiply rapidly and are later liberated in the soil upon the death and decay of the affected plants. In the soil the bacteria can remain alive for a long time even without any susceptible growing host, thus making it impossible to grow eggplants and other susceptible crops profitably in the same field from one year to another.

Control.—The bacterial disease of eggplant and its relatives are very difficult to control. The control of this disease by destroying the parasite in the soil with chemical agents is not only impractical but also very expensive to follow in big-scale planting of eggplants. The treatments of soils with acids or alkalies in amounts sufficient to kill the organism render the soil unfit for the cultivation of many plants, hence, no benefit is obtained from this method. The most effective control so far found for this disease is strict sanitation, systematic crop rotation and planting of resistant varieties.

A system of crop rotation in which no eggplant or any of the wilt-susceptible hosts are planted for at least three or four years, is highly beneficial. Such plants as tobacco, pepper, tomato, potato, tañgo, castor bean, cosmos, marigold, and cockscomb have been reported in the Philippines as susceptible to bacterial wilt and should, therefore, be excluded in the crop series. As a precautionary measure, the following cultivated plants such as watermelon, velvet bean, sweet potato, cowpeas, soybeans, peanuts, and peas and ornamental plants such as dahlia, petunia, and sunflower have been reported in other countries as subject to the attack of wilt organism and should not also be included in the rotation system. In order to completely starve out the

organism, such weeds as unti-untian (*Physalis minima*), potókan (*Physalis angulata*), kolites (*Amaranthus gangeticus*), damong pallas (*Ageratum conyzoides*) and *Spilanthes acmella* which also serve as hosts of the disease should not be allowed to grow in the field. Rice, sugar cane, corn, cotton, garlic, ginger, gabi, ubi, tugue, casava, sincamas, tapilan, and derris are not known to be affected by the disease and can, therefore, be used in the rotation system.

No eggplant variety has as yet been found to be immune to the wilt disease. However, such varieties as Big Japanese Purple (Plate 4), Pampanga White and certain strains of Big Japanese Purple × Native Long when planted in wilt-infected field appeared to be very resistant to the disease. The only objection to Big Japanese Purple and Big Japanese Purple × Native Long is that they are among the varieties found to be most susceptible to Phomopsis disease. Iloilo Purple was also observed to be moderately resistant to the wilt disease.

PHOMOPSIS DISEASE

The Phomopsis disease is widespread in the Philippines. It may occur on eggplants at any time of the year but it usually attacks them more seriously during the rainy or humid months than during the dry months.

Symptoms.—The Phomopsis disease attacks all parts of the eggplant above the ground, producing different types of symptoms on different parts.

The disease on the seedlings originates usually from infected or contaminated seeds. Seedlings affected damp-off, fall over, and die.

On the stems of mature plants the disease produces brown or light brown, oblong or irregular, sunken, dead areas which with age develop into a form of dry rot or canker. Plants seriously attacked by the disease on the main stems wilt and die prematurely. When a tender stem is attacked the affected part shrinks rapidly and sometimes tips over because the weakened tissues are unable to support the weight of the foliar part. In later stages of the disease the affected parts of the stems may be covered by minute, black pustules, the fruiting bodies of the causal fungus.

On the leaves, the disease produces irregular brown spots with blackish brown margin (Plate 5, fig. 1). These spots are shown more conspicuously on the lower, older leaves than on the upper, younger ones. The presence of many of these spots

cause the dropping-off of the leaves, hence on seriously attacked plants only the younger, upper leaves are usually left (Plate 1, fig. 3). On old spots minute, black pustules are also produced.

On the fruits the disease produces soft, sunken, light brown depressions which tend to merge together, when numerous, into large dead areas (Plate 5, fig. 2). Numerous black pustules (Plate 5, fig. 3) develop on the rotting parts of the fruit. Under dry weather conditions the rotting fruits shrink fast and mummify as black, hard bodies.

Cause.—The Phomopsis disease is caused by a fungus known as *Phomopsis vexans* (Syd. & Sacc.) Harter. The organism produces fruiting bodies which appear as minute, black pustules on the attacked parts of the eggplant. Within these black bodies are numerous spores which correspond to the seeds of the higher plants.

Control.—Since the disease is seed-borne, it is absolutely necessary to obtain the seeds from healthy, vigorous plants. Seeds of an unknown source should be soaked in a solution of corrosive sublimate (one gram in 1000 cc. of water) for 10 minutes or in a solution containing one part of commercial formalin and 300 parts of water for 15 minutes before planting. In the absence of the above disinfectants the seeds should be soaked in hot water for 30 minutes at 50° C. or for 10 minutes at 55° C.

As soon as the crop is over, the plants in an infected field should be pulled out and burned to kill the organism and eliminate the source of infection for other fields of eggplants in the neighborhood. Eggplants should not be planted in severely infected fields for at least three years in order to starve out the causal fungus.

Spraying with Bordeaux mixture (bluestone, 1 kilo; quick lime, 1 kilo; water, 100 liters) 5 or 6 times at weekly or biweekly intervals has been found satisfactory in controlling the disease in the field. The first spraying should be given as soon as the early symptoms are noticed. For effectiveness of the spray, it should be applied in fine mist with a compressed air sprayer or hand pump and should be directed to the stems and lower and upper surfaces of the leaves.

The selection and planting of resistant varieties or strains should also be done as a means of controlling the disease. The Pampanga White Variety has been observed to be very resistant to the Phomopsis disease but resistance to this malady does not

insure its resistance to the Phytophthora disease to which its fruits were found to be very susceptible. Iloilo Purple and Lemery varieties were observed to be fairly resistant to Phomopsis disease.

PHYTOPHTHORA DISEASE

The Phytophthora disease is frequently the cause of severe rotting of the fruits in the field during wet weather. No serious case of this disease was observed during hot weather. At the Lipa Coffee-Citrus Station it destroyed about 50 per cent of the fruits of the Pampanga White variety during the months of September and October, 1937.

Symptoms.—The Phytophthora disease attacks both the leaves and fruits. On the leaf it appears in the form of large, blighted areas which sometimes involve the entire leaf. No serious cases of blighting of the foliage due to this disease were observed in the field.

On the fruits the disease is more commonly found on low-hanging ones than on those set on the upper branches, indicating that the source of infection is contaminated soil. Affected fruits show circular to irregular dark-brown patches which are usually a few millimeters in diameter. During moist weather the diseased areas enlarge rapidly until the entire fruit rots. A distinct cotton-like growth of the causal fungus (Plate 6, figs. 1 and 2) usually develops on the rotting tissues. With age the cotton-like growth becomes flat and turns into a dirty-white felt on the surface of the diseased areas. Badly attacked fruits drop off from the calyx-lobe and then disentigrate.

Cause.—The Phytophthora disease of eggplants is caused by a fungus known as *Phytophthora melongenæ* Sawada. The white cotton-like growth that develops on the rotting fruits consist of mycelium or vegetative parts and spores or the seed bodies of the fungus. Upon the disentigration of the diseased leaves and fruits, the fungus is left in the soil where it may remain alive until the next season. The fungus is carried from one place to another with the soil and debris on farm implements, feet of men and animals and by surface water during the rain. From the soil the fungus is splashed with soil particles to the leaves and fruits and cause infection if conditions are favorable for the development of the fungus.

Control.—The Phytophthora disease can be controlled by spraying with 4-4-50 Bordeaux mixture once every two weeks or oftener during the rainy season. In a place where this

disease is already known to occur, spraying should begin as soon as the young fruits are formed. The plants should be examined from time to time and as soon as the disease is detected the affected parts should be removed and then buried or burned in pits. This procedure will prevent too much contamination of the soil, and also, will reduce infection for the forthcoming fruits. The disease may also be greatly minimized by planting the eggplants at least one meter apart in order to establish conditions less favorable to the development of the disease by permitting free circulation of air and admitting plenty of sunshine.

ROOT-KNOT

Root-knot is one of the most widespread diseases of our cultivated plants, weeds and many grasses. Plants cultivated in light, sandy or loamy soils are more seriously affected with root-knot than those grown in heavy clay. Prolonged high soil temperature seems to favor serious outbreaks of this disease.

Symptoms.—The disease may readily be recognized by knot-like enlargements or swellings on the root system (Plate 7, fig. 1). The enlargements may vary in size from small knotty appearance on finer roots to large, elongated swellings on bigger roots. The presence of the swellings slows down the movement of the food supply of the plant, hence, badly affected plants show pale green or light yellow leaves and appear dwarf or stunted. Seriously affected plants wilt, especially during dry, hot weather and may die after several days. The disease attacks eggplant in any stage of its growth. Plants infected during their seedling stage may die before they develop many leaves or produce many fruits. Plants infected during their mature stage may continue to produce some fruits but such plants show slower growth and lighter green leaves than healthy ones.

Cause.—Root-knot is caused by *Heterodera marioni* (Cornu) Goodey = *Heterodera radicicola* (Greef) Müller, a minute animal commonly called nematode or eelworm (Plate 7, fig. 4). The young eelworms work their way through the soil and invade the plants they prefer by boring into the roots. The presence of these animals in the tissues irritate the plants causing them to form knot-like swellings on the roots. Upon breaking the old swellings, minute, pearly, white, pear-shaped bodies may be seen. These bodies are the enlarged egg-bearing female nematodes. A mature female (Plate 7, fig. 2b) may lay hundreds of eggs (Plate 7, figs. 2a & 3) which hatch within the root-knot

tissues into active forms or eelworms. Upon the disentigration of the root-knot tissues the eelworms escape and live for sometime in the soil until they come in contact with the fresh roots of susceptible plants.

Control.—A three-year crop rotation, which is accompanied by clean cultivation to eliminate the weed hosts of the nematodes and in which only immune and highly resistant crops are planted, is the most satisfactory method of controlling root-knot in an infested field. Peanuts, onions, parsnip, turnip, garlic, sincamas, seguedillas, rice, corn, and velvet bean are either immune or highly resistant to root-knot and, therefore, may be grown in rotation system. Proper precautions should be taken to prevent the occurrence of the disease in seedbeds by sterilizing the soil or using only soil known to be free from nematodes. Seedbeds should be located in newly opened grounds and where this cannot be done, the soil should be sterilized with either steam or chemicals. Seed flats can be rid of nematodes by pouring boiling water (about one kerosene can of boiling water in a flat (18 × 24 inches) into the soil. Root-knot infection may also be greatly reduced by flooding the infested field for thirty-five to forty days and also by constant stirring and exposing the infested soil to the sun during the dry, hot weather.

STEM-ROT

Stem-rot is a very common disease of our cultivated and weed plants. No serious outbreak of stem-rot of eggplants was observed in the field, but once the plants are attacked by this disease, they are usually killed.

Symptoms.—The disease is characterized by rotting of the tissues at the base of the plant. Under humid conditions an abundant growth of fine, white mycelial threads may be seen covering the brown rotting tissues (Plate 2, fig. 3). Numerous spherical bodies which are white while young and brown with age develop on the mycelial web. The presence of these bodies, which are about the size of mustard seeds is the most important diagnostic sign of the disease. Affected plants wilt and die usually after the mycelial web has completely encircled the stem.

Cause.—The stem-rot of eggplant is caused by a fungus known as *Sclerotium rolfsii* Sacc. The spherical bodies which develop on the mycelial web are known as sclerotia. The sclerotia are the usual means of propagating the fungus and are very resistant to adverse weather, hence, they serve in the same way as

seeds in carrying the fungus from one season to another. When the conditions are favorable for their growth, they germinate and cause infection when they come in contact with susceptible plants.

Control.—Since the causal fungus attacks a large variety of plants, crop rotation as a control measure is very impractical. The most practical method of controlling stem-rot is careful removal of the affected plants together with the sclerotia and then dumping and burning them in pits. Other important measures are clean culture, avoidance of close planting in infected field and prevention of the spread of the fungus to uninfected places.

MINOR EGGPLANT DISEASES

The other diseases of eggplants which have been reported in the Philippines are generally considered of minor economic importance. Those which are well known are anthracnose caused by *Gloeosporium melongenæ* Sawada, rust, caused by *Puccinia tubulosa* (P. & G.) Arth., and leafspot caused by *Cercospora melongenæ* Welles. Anthracnose causes blighting of the leaves and shoots and also rotting of the fruits. Rust and leafspot attack mostly the leaves.

Planting of healthy seeds, strict sanitary measures, proper cultural methods and crop rotation will hold any of the above diseases in check. Should any one of them show sign of becoming serious because of unusual weather conditions, the plants should be sprayed with 4–4–50 Bordeaux mixture. The applications of this spray should follow in all their details those for the control of Phomopsis disease on eggplants in the field.

ILLUSTRATIONS

PLATE 1

FIG. 1. A garden containing different varieties of eggplants badly attacked by both Phomopsis disease and Phytophthora disease. Note the number of fruits that have fallen due to these two diseases.

2. Eggplant fruits gathered from the garden shown in fig. 1. Healthy fruits (left), fruits attacked by Phomopsis disease (middle), fruits attacked by Phytophthora disease (right).

3. Japanese Purple eggplants heavily defoliated by Phomopsis disease.

PLATE 2

FIG. 1. Showing infection of eggplant seedlings by damping-off due to *Rhizoctonia solani.*

2. Damping-off of eggplant seedlings due to *Sclerotium rolfsii.* Note the white mycelial growth of the fungus and the formation of young sclerotia which appear as small, white, spherical bodies on the mycelial web.

3. Basal portion of the main stem of eggplant affected with stem-rot. Note the white growth of the causal fungus *Sclerotium rolfsii* on the rotting part of the stem.

PLATE 3

FIG. 1. An eggplant showing the early signs of wilt disease caused by *Bacterium solanacearum.* Note the drooping of a number of leaves on the upper left part of the plant.

2. An eggplant showing prominently the signs of wilt disease due to *Bacterium solanacearum.*

PLATE 4

Eggplants grown in wilt-infected field. The Isabela variety (two rows at left) is very susceptible to the wilt disease caused by *Bacterium solanacearum* while the Japanese Purple variety (two rows at right) seems to be highly resistant to the same disease.

PLATE 5

FIG. 1. An eggplant leaf showing the typical leaf-spot symptoms of Phomopsis disease.

2. An eggplant fruit attacked by Phomopsis disease.

3. A portion of an eggplant fruit attacked by Phomopsis disease showing the development of numerous black pustules, the fruiting bodies of the causal fungus (*Phomopsis vexans*).

PLATE 6

FIG. 1. Phytophthora disease on Pampanga White fruits of different stages. Note the cotton-like growth of the causal fungus *Phytophthora melongenæ.*

2. Phytophthora disease on an eggplant fruit of the Lemery variety. Note that the entire fruit is almost covered by the cotton-like growth of the fungus.

PLATE 7

FIG. 1. Root system of an eggplant showing the root-knot disease caused by an eelworm *Heterodera marioni.*

2. Egg sack (*a*) and mature female of root-knot nematode (*b*), about × 54.

3. Various stages in the development of the egg of root-knot nematode, about × 204.

4. Larva or young nematode. This is the most active part in the life-cycle of this animal, about × 134.

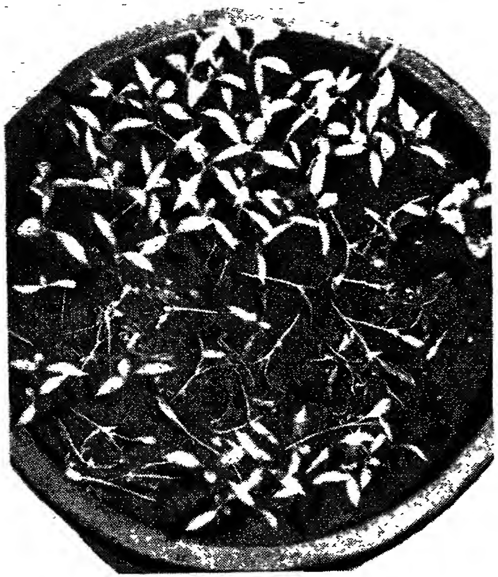
5. Mature male nematode, about × 135.

1

2

3

PLATE 1



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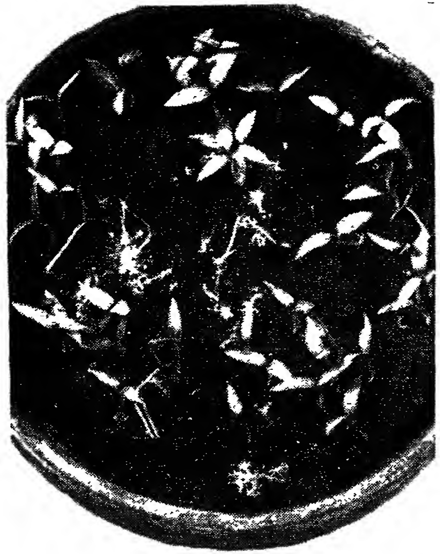


2

3

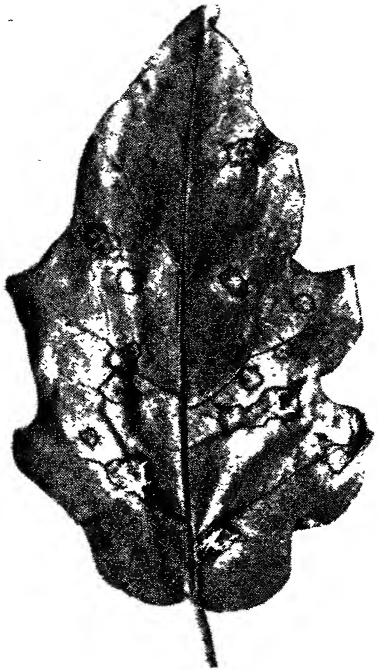
PLATE 2

1

2

PLATE 3

PLATE 4



1

2

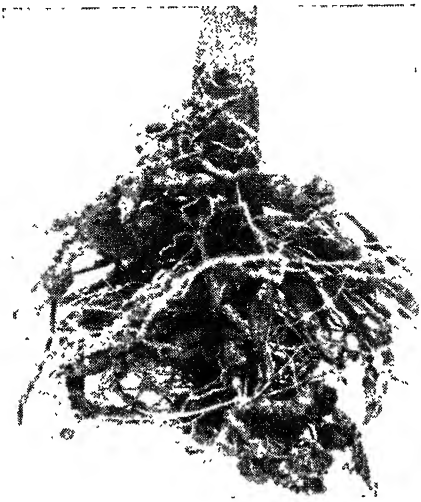
3

PLATE 5

1

2

PLATE 6



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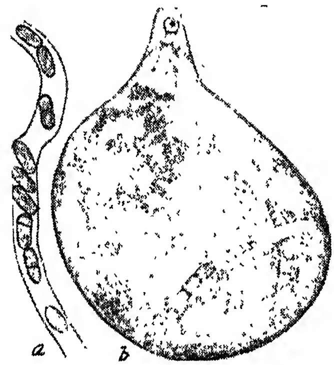

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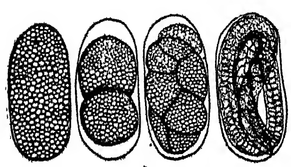

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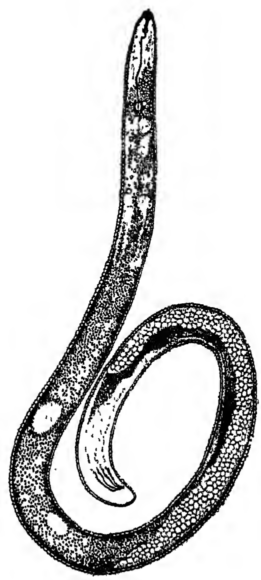

5

PLATE 7

BUREAU OF PLANT INDUSTRY

AGRICULTURAL STATIONS

1. Central Experiment Station, Manila
2. Lamao Horticultural Station, Limay, Bataan
3. Lipa Coffee-Citrus Station, Lipa, Batangas
4. Tanauan Citrus Station, Tanauan, Batangas
5. Granja Sugar-Cane Station, La Granja, Occidental Negros
6. Gandara Seed Farm, Gandara, Samar
7. Baguio Plant Industry Experiment Station, Baguio
8. Maligaya Rice Station, Muñoz, Nueva Ecija
9. Ilagan Tobacco Station, Ilagan, Isabela
10. Maridagao Rubber Station, Pikit, Cotabato
11. La Paz Propagation Station, La Paz, Iloilo
12. Los Baños Economic Garden, Los Baños, Laguna
13. Sta. Maria Propagation Station, Sta. Maria, Ilocos Sur

SUBSTATIONS

1. Davao Seed Farm, Davao Penal Colony, Davao
2. Halcon Rubber Substation, Baco, Mindoro
3. Gingoog Lanzon Reservation, Gingoog, Oriental Misamis
4. Mandaue Seed Farm, Mandaue, Cebu

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